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THE ROLE OF TRACE ELEMENTS IN MANAGEMENT OF NUISANCE GROWTHS

Ruth Patrick, et al

Academy of Natural Sciences of Philadelphia

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To carry out this program of study, the following trace metals were examined: vanadium, chromium, selenium, boron, nickel, and rubidium.

The results of these experiments indicate the concentration and form of a trace metal may have a definite effect upon which algal species can out-compete others. These shifts may greatly reduce the productivity of the system as a whole. If the shift is to species which has such lower predator pressure, large standing crops which may be nuisances may develop.

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THE ROLE OF TRACE ELEMENTS IN MANAGEMENT OF NUISANCE GROWTHS

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SECTION I

CONCLUSIONS

A review of the literature shows that various concentrations of trace metals greatly influence the growth of various species of algae in laboratory experiments. For example, Arnon and Wessel[1] found that vanadium improved the growth rate of Scenedesmus. The addition of 20 micrograms per liter (ug/l) of vanadium increased the dry weight of this alga almost four-fold. However, vanadium has not been found to be an essential trace element for Nostoc muscorum, Calothrix parietina, or Anabaena cylindrica (Holm-Hansen[2], Allen[3]). Gerloff[4] has found that boron in concentrations of 0.27 milligrams per liter (mg/l) favored the growth of Calothrix parietina and Nostoc muscorum. The growth rate of Chlorella vancelli was reduced in a concentration of 50 mg/l, and Drapanaldia plumosa and Stigeoclonium tenua were not stimulated by the addition of 0.27 mg/l. Experiments with nickel indicate that the anion with which it is associated seems to have an effect on its toxicity. Scenedesmus sp. had a threshold toxicity of 0.09 mg/l if nickel was in the form of nickel ammonium sulfate, whereas nickel chloride was less toxic with a threshold concentration of 1.5 mg/l.

The importance of the form and concentrations of various trace metals in influencing the occurrence of certain species of algae and the resulting effect on the structure and productivity of the aquatic ecosystems has not been previously researched. The literature clearly indicates that various organisms have various algal food preferences.

For example, diatoms and various unicellular algae are often the preferred food of invertebrates and vertebrates such as mayflies, caddisflies, and various kinds of fish. In contrast, blue-green algae and various kinds of filamentous green algae are less desirable food sources.

The experiments described in this report clearly indicate the importance of trace metals in causing shifts from diatom-dominated to blue-green dominated communities. For example, vanadium in concentrations up to approximately 20 ug/l seemed to favor diatom growth. Above this concentration vanadium was not as favorable for diatom growth, and other kinds of algae--particularly some of the filamentous greens and blue-greens--increased. At approximately 4 mg/l blue-green algae were able to out-compete diatoms. This shift in the effect of vanadium on the growth of diatoms seemed to be correlated with the accumulation of vanadium within the biomass.

Similar results were seen in our study of chromium; at 40 to 50 ug/l the diatoms remained dominant throughout the experiments and the diversity was high. At average concentrations of 95-97 ug/l the diatom diversity was reduced although the diatoms remained dominant; whereas at average concentrations of 397 ug/l diatoms were completely replaced by blue-green algae and Stigeoclonium lubricum.

In the boron experiments a shift from the diatom-dominated communities to ones in which blue-greens became more common occurred as concentrations approach 1 mg/l which is somewhat higher than the 0.37 mg/l which

Gerloff[4] and Eyster[5] found to increase blue-green algal growth. Nickel at all concentrations was unfavorable to the growth of diatoms, whereas green algae such as Stigeoclonium lubricum, which is known to tolerate heavy metals, and certain of the blue-green algae increased. Thus it is evident from these experiments that in most cases certain species of blue-greens and the green alga Stigeoclonium lubricum seemed to be more tolerant than diatoms of trace metals.

In the many river surveys carried out by the Academy of Natural Sciences, it has been observed that Stigeoclonium lubricum would often develop fairly large populations under conditions of low toxicity where other algae could not grow.

In other experiments it was the form of the trace metal that was more toxic to one group of algae than another. This was illustrated in the case of selenium wherein it has been demonstrated by Kumar and Prakash[6] that selenate is less toxic than selenite to blue-green algae. In contrast, our experiments showed that selenate at all concentrations tested was detrimental to diatom growth, but selenite at concentrations of 1-10 mg/l was stimulating to diatom growth and at high concentrations became detrimental. Thus in considering the effects of trace metals one has to consider not only the element but the form that it is in.

In many cases it would appear that the effect of these trace metals on diatom growth is somewhat toxic, whereas often blue-green algae and in a few cases Stigeoclonium lubricum were not adversely affected as their growth increased. In a few cases such as vanadium and selenite at low concentrations diatoms seemed to be stimulated by the presence of these trace metals. The physiological role that these metals play is not well understood and needs further research.

The results of these experiments seemed to indicate that the amount of a given trace element that is accumulated within the cells was often a more important determining factor as to whether or not the diatoms were adversely affected than was the concentration within the water in which the diatoms were living. In most cases the concentration in the water was correlated with the amount accumulated. However, environmental conditions and the condition of the algal cells sometimes affected these correlations. For example, environmental factors such as temperature and day length, if favorable for diatom growth, seemed to have a definite effect on whether the diatoms divided and thus have an effect upon the accumulation of the trace metal per cell. When the diatoms were rapidly dividing the amount per cell accumulated was less and as a result, although there might be more trace metal accumulated in the biomass, the amount of micrograms per gram (ug/gm) of biomass is less.

These experiments also indicated that one of the first signs of adverse effects of a trace metal upon the diatoms was the amount of ^{14}C accumulated per microgram of chlorophyll $_a$. It would appear that in many cases there was a threshold amount of trace metal accumulated above which the ^{14}C uptake was reduced. It also appeared that the amount of reduction might be affected by other density independent factors.

It is evident from these experiments that trace metals may have a profound effect on the diversity of the food web and the transfer of nutrients through it. Although nitrogen, phosphorus, carbon, etc., are very important in the formation and in the increase of protoplasm, it is the concentration and forms of various trace elements that are important in determining what algae utilize these nutrients.

Furthermore, invertebrates and fish have various species of algae as preferred food. For example, few invertebrates and fish prefer blue-green algae and many kinds of filamentous green algae. The preferred algal species are diatoms and some unicellular green algae. Among these groups some species are more preferred than others.

The concentrations and kinds of trace metals that favor blue-green algae and certain filamentous green algae bring about large standing crops which have very little predator pressure and may become nuisance growths. To recycle the nutrients tied up in these species, decomposition must take place. Entropy in the system is increased and diversity is reduced. The system is simplified as the higher stages of the food web cannot be maintained by the transfer of nutrients to the herbivores.

SECTION II

RECOMMENDATIONS

The results of these studies would indicate that in considering the occurrence of nuisance growths within the aquatic ecosystem considerable attention should be paid to what are the factors which influence the kinds and concentrations of various trace metals. For example, 1-10 parts per million of selenium as selenite and a few micrograms of vanadium will favor diatom growth. Larger concentrations of vanadium (4 mg/l) and of chromium (0.4 mg/l) may be deleterious to diatom growth and may favor the development of blue-green algae.

In the management of our streams attention should be given to the proper mix of trace metals present in order to maintain the species with high predator pressure that will increase the nutrients flowing through the food web, and result in higher productivity of fish rather than in the production of nuisance growths. Factors which tend to precipitate out and make unavailable the trace metals may be in some cases as deleterious as those factors which increase their concentrations in the system. Stream management which is necessary to maintain normally functioning streams in areas of high usage should include the control of proper concentrations of trace metals.

Further research is needed to understand just how these elements function within the algal species and what mixtures of them are most important for supporting desirable algal species under varying "density independent" factors.

SECTION III

INTRODUCTION

During recent years there has been considerable interest in the eutrophication of surface waters or what causes the large growths of algae and rooted aquatic plants. This growth has been attributed to the supplying of one or more limiting chemicals to the water which contain the other nutrients necessary for growth. In fresh waters phosphorus often has seemed to be the limiting element, whereas in brackish or sea water nitrogen is often the limiting element.

Most people have attributed these large increases in standing crop to nutrient enrichment. Few have discussed the role of predator pressure in greatly reduced standing crops, or in the absence of predators the accumulation of large standing crops. Patrick[7] conducted a series of experiments on diatom communities. In these experiments various forms of nitrogen and phosphorus as phosphate were used. Various concentrations and various ratios of these elements were tested. Although the diatom growth was increased in some tests, there was not a shift from diatom-dominated communities to those dominated by filamentous greens or blue-greens.

Many papers have shown that certain trace elements may increase or decrease the production of certain algal species. These results led to the posing of the question, could increasing or decreasing the amount of certain trace elements cause a shift in the species composing a community of diatoms which are species subjected to high predator pressure to filamentous greens or blue-green algae which have low predator pressure.

To test this hypothesis a series of experiments was designed to determine the effects of varying concentrations of boron, nickel, vanadium, chromium, rubidium, and selenium on the structure of algal communities.

SECTION IV

LITERATURE REVIEW

An examination of the literature shows that various forms and concentrations of trace elements may have a profound effect upon the growth of various species of algae.

BORON

The effect of boron on algal growth seems to vary with the species and perhaps with the race or variety of the species tested. The method of experimentation may also be the cause of some difference in results. Gerloff[4] reports that the growth of *Calothrix parietina* (a nitrogen fixer) is increased when 0.27 mg/l of boron is added to the nutrient solution. The boron within the cells increased from 2.35 ug/gm to 255 ug/gm. He further reports that an increase in growth and a deepening color was produced in *Nostoc muscorum* when grown in a nutrient solution containing 0.27 mg/l boron. The boron in the cells increased from 0.92 ug/gm in the boron-free media to 25 ug/gm in the boron-added media. Eyster[5] reports that 9×10^{-5} M boron (about 0.1 mg/l) is optimum for this species. *Anabaena cylindrica* (a nitrogen fixer) and *Microcystis aeruginosa* (a non-nitrogen fixer) did not show significant improvement in growth.

The growth of green algae does not seem to be greatly improved by the addition of boron. Several studies have been done on *Chlorella* with conflicting results (McIlrath & Skok[8]; McBride, *et al*.[9]). Bowen, *et al*.[10] found that 50 mg/l of boron significantly reduced the growth rate of

Chlorella vancelli. Gerloff[4] reports that Draparnaldia plumosa and Stigeoclonium tenua were not stimulated by the addition of 0.27 mg/l of boron. Lewin[11] postulated that boron is essential for all fresh and saltwater diatoms and that freshwater diatoms have a lower requirement than marine ones. She found that a maximum growth of Cylindrotheca fusiformis was supported by 0.5 mg/l boron, that up to 40 mg/l was not inhibitory, but 80 mg/l produced some inhibition. There seemed to be some correlation between the concentration of silicates and boron required for growth.

CHROMIUM

The importance of chromium to aquatic life in minute concentrations has occasionally been investigated. The research on this element is far less than that on boron. Mertz[12] stated that the data from the U.S. Geological Survey indicates that in a study of 15 rivers in North America the chromium content varied from less than 0.7 ug/l in the Sacramento River to 84 ug/l in the Mississippi River. In the Mississippi, samples taken a year apart varied thirty-fold.

Trivalent chromium seemed to stimulate enzymatic activity. It has been reported to stimulate oxygen consumption in a succinic-cytochrome dehydrogenase system. The enzyme phosphoglucomutase, which has an important function in the early steps of glucose metabolism, has a chromium requirement.

The data on the effect of plants are very limited. When chromic sulfate was applied to grape vines (bushes) the yield of grapes increased and the sugar content increased 23 percent (Mertz[12]). The alga Stigeoclonium sp. in the Columbia River, has been shown to concentrate chromium 4,000 times the concentration in the river water, but the effect on the algae was not determined (Zajic[13]).

The threshold toxicity for trivalent chromium was 5 mg/l for Scenedesmus (Bringmann and Kühn[14]). Hexavalent chromium (Clendenning and North[15]) affected the photosynthetic rate in the giant kelp (Macrocystis pyrifera) 10 to 20 percent after 5 days' exposure and 20 to 30 percent after 7 to 9 days' exposure at 1 mg/l of chromium.

There is evidence that chromium and manganese at concentrations of 3 ppm have a synergistic effect and stimulate spore production in bacteria (Mertz[12]). However, 1 ppm of dichromate was toxic to Staphylococcus aureus. These data indicate that the valent form of chromate has various effects and that species vary in their reaction to different concentrations of chromium. Chromium has been reported to stimulate the fermentation in yeast in concentrations of 150 ppm or more. The addition of glucost seems to stimulate the incorporation of chromium (0.0001 to 1 ppm) in brewers yeast cells (Mertz[12]).

NICKEL

There seems to be very little data concerning the effect of nickel on algal growth. Bringmann and Kühn[14] found that threshold toxicity of Scenedesmus sp. was 0.09 mg/l of nickel ammonium sulfate ($NiSO_4(NH_4)_2SO_4 \cdot 6H_2O$). They found that nickel chloride was less toxic, the threshold concentration being 1.5 mg/l for Scenedesmus sp.

RUBIDIUM

Very little research has been done on the effect of rubidium on algae. Zajic[13] sets forth the results of experiments of Bertrand and Bertrand. Chlorella pyrenoidosa has been shown to selectively absorb rubidium over potassium and sodium. Baum and O'Kelley[16] investigated the ability of 21 species of algae to substitute rubidium for potassium. They found that 11 species did not utilize rubidium when substituted for potassium in the medium, two species were strongly inhibited by rubidium, and six species partially utilized rubidium when substituted for potassium. Of these, Chlamydomonas reinhardtii responded best. The only difference was that the motility of cells was impaired when rubidium was substituted for potassium. Bringmann and Kühn[14] found that 14 mg/l of rubidium added as rubidium chloride were toxic to Scenedesmus.

SELENIUM

The effect of selenium on organisms seems to vary depending on its concentration and whether it is in the form of selenite or selenate. Various higher plants may accumulate considerable amounts of selenium whereas other plants accumulate very little. In non-accumulator species over half of the selenium is in the form of selenomethionine (Butler and Peterson[17]). In accumulator species selenocystathionine and selenium-methyl selenocysteine are the major compounds.

Not very much is known about the action of selenium compounds on algae. However, selenium affects algae in various ways. Kumar and Prakash[6] found that selenite at various concentrations was more toxic than selenate to Anacystis nidulans and Anabaena variabilis. Of the two blue-greens, A. variabilis was more sensitive than A. nidulans to both forms of selenium. Experiments were carried out in liquid cultures with and without sulfur added, and in plate cultures with sulfur added. A. nidulans is three times more tolerant to selenite and selenate killing than is A. variabilis. The addition of sulfur seems to in part counteract the deleterious effect of selenium.

The effects of selenium in dying cells were to repress cell division, bleach photosynthetic pigments, and increase vacuole formation; and granules became evident in the cytoplasm. Recent work indicates that selenite may oxidize sulphydryl enzymes in the absence of sulfur.

Experiments as to the effect of selenium on Chlorella vulgaris were carried out by Schrift[18]. He found that 2.5 ppm of selenate with 10 ppm of sulfur was only slightly inhibitory to cell division, whereas 10 ppm of selenate plus 10 ppm of sulfur reduced cell division rates 58 percent. Bringmann and Kühn[14] have found that Scenedesmus exposed at 24°C for four days to 2.5 mg/l selenium as sodium selenite was at a medium threshold level of toxicity.

VANADIUM

In algae, the requirement for vanadium seems to be variable. Holm-Hansen[2] did not find it an essential trace element for Nostoc muscorum or for Calothrix parietina. This conclusion as to its importance for blue-green algae is supported by the work of Allen[3] on Anabaena cylindrica. However, Arnon and Wessel[1] found that the growth rate of Scenedesmus was greatly improved with the addition of 10-100 mg/l of vanadium. There was evidence that vanadium affected the amount of chlorophyll present but the effects were not as definite as they were in the case of molybdenum. Gerloff[4] states that Chlorella does not require vanadium.

SECTION V

METHODS AND PROCEDURES

The purpose of these experiments was to study natural diatom-dominated algal communities under as nearly natural conditions as possible. In order to carry out these experiments, a set-up had to be devised in which a series of very similar algal communities could be developed in different test chambers. These communities were mainly diatoms but a few green algae and blue-green algal species with relatively small populations were usually present. The light, temperature, and invasion rate of the diatoms must be the same or very similar. This system has been previously devised and described by Patrick[19].

The biomass determinations and accumulation of metals determinations were the same throughout the experiments. The phycocyanin determinations in the beginning of the experiments had many problems in pigment extraction from the very small filaments and with interference of other pigments. Therefore the pattern of change is important rather than absolute values. In the later experiments phycocyanin was determined as micrograms per a unit of area or weight of biomass, and degrees of change are more reliably estimated.

In this particular series of experiments two types of procedures were used. In the first type the seeding or establishing of diatom communities was done using a continual flow of new stream water. After the diatom communities were established on the slides, which usually took from ten days to two weeks during the period from March to November and usually three to four weeks from the period November to early March, they were exposed to a given chemical. Often duplicate containers received the same amount of the same chemical. In other cases, each box received a different concentration. One or two controls were always run--that is, boxes that received no chemicals. During the test period the chemical in a fairly concentrated amount was metered into a mixing chamber to which was added dilution water at a rate approximating one-third to one-half foot per second--usually nearer one-half foot per second. Flow was kept constant during the experiments so that the concentration of the chemical would be as nearly constant as possible. This mixture, after being thoroughly mixed with a high degree of dilution, was then circulated through the boxes containing the diatom communities.

In the second series of experiments where much lower concentrations of chemicals were under test or where given concentrations of a chemical were extremely hard to maintain, recycling of the water was necessary. In such cases the seeding of the experiment, as in the first procedure, was carried out using a continual flow of new stream water through the boxes until the diatom communities were well established. Once this was done the system was closed and the water was recycled through the boxes. However, 1.5 liters per hour (l/hr) of new water was added which had been carefully filtered to remove most of the diatoms. It was impossible to remove all of them. This was done so that most of the diatoms in the experiment were only those that had been continually exposed to the concentration under test. It was found necessary to add this new water because no one has been able to maintain a mixed diatom community composed of a great many species over a long period of time in a synthetic medium. The water added to each container was taken from the same larger container so that the same type of water was always added. This addition of new water caused a complete replacement of water in the system every two days.

The pH and temperature were continually recorded during the test. The pH and temperature recorders were checked each day for accuracy. The regime for testing the other chemicals is set forth in the accompanying tables. It was found in previous experiments that the concentration of certain chemicals such as calcium, magnesium, sulfate, chloride, sodium, and potassium varied little during the course of the tests. For these reasons they were not frequently tested. The chemical under test was tested at least five days out of each week, but in some cases where concentrations were hard to maintain, daily--or even more frequent than daily--determinations were made. Other chemicals varied in their frequency of testing. Those more frequently tested were nitrates, phosphates, silica, manganese, and iron. It was found that ammonia was usually present in extremely small concentrations and did not vary as much as nitrates. For this reason it was not tested as frequently. Atomic absorption methods were used for determining the concentrations of metals. Since it has been established (Patrick, Crum and Coles[20]) that low amounts of manganese may favor the development of blue-green algae in the White Clay Creek where these experiments were carried out, it was deemed wise to test this element very frequently to make sure that it was maintained at a concentration that would not favor the development of blue-green algae.

During the course of these tests observations were made of the condition of the algae and associated organisms at frequent intervals. All slides in every box were examined at the end of the seeding period to make sure that the relative abundance of diatoms to greens and blue-greens was similar. During the course of the test, often twice a week but at least once a week, the slides were examined microscopically to determine what were the shifts in composition of the algal flora. Thorough examinations were made at least three times during the experiment (Tables 1-22). Observations were also made on protozoa and other microscopic animals that were present. These observations are not herein recorded except when something exceptional was noted.

In these experiments it was found that a fairly large predator pressure might develop on the algal communities. This predator pressure was mainly that of aquatic insect larvae. For these reasons daily, or almost daily (the frequency depending upon the abundance of the insect larvae), the slides were carefully examined under a microscope and all predators removed. It was, of course, impossible to remove the protozoan predators. These were carefully observed as to what they were eating. In most cases the protozoans that developed on the slides were largely bacterial feeders. However, in the case of some of the ones that were predators on diatoms the kinds of diatoms they were eating were noted. At the end of the experiment as set forth below, the biomass, the primary production, and the pigment of the algae were recorded. In cases where a diatom community was present at the end of the experiment and consisted of a fairly large number of species, diversity studies were made. However, in other cases where the community was taken over by other forms of algae such as species of blue-greens, it was not necessary to make such studies as the diatom community was absent or present only to a limited degree.

PRIMARY PRODUCTIVITY - ^{14}C UPTAKE

^{14}C determinations were carried out on all experiments except boron. These facilities were not available when that series of concentrations was tested. Experiments with chromium, rubidium, and selenium were conducted in the following manner.

A single slide was selected from each test unit for determining the amount of primary productivity. The community on one side was removed and placed in a petri dish with 35 milliliters (ml) of water from the test system for dark incubation. The community still intact on the other side was placed in a second petri dish with 35 ml water from the system. Isotope ($NaH^{14}CO_3$, New England Nuclear, Boston, Mass., sp. act. 8.4 mCi mM^{-1}) was added to each dish to provide a final concentration of 1 uCi in 35 ml. The sample for dark incubation was covered immediately with aluminum foil. Incubation was conducted for 1 to 2 hours around solar noon under naturally occurring temperature and light conditions. Incorporation was terminated by adding 1 ml of 37 percent formaldehyde.

A sample (10 ml) of the water from the sample incubated in the light was taken; membrane filtered (0.45 u pore size, Millipore Corp., Bedford, Mass., at 0.5 atm.), acidified with 0.5 ml 0.5 N HCl to pH 3.0, bubbled for 30 minutes to drive off unincorporated bicarbonate, and neutralized with 0.5 ml 5 N NaOH. The ^{14}C remaining in the water as organic material excreted by the algae was determined by liquid scintillation counting of a 3 ml subsample in a toluene-Omnifluor (New England Nuclear, Boston, Mass.)-Triton X (Beckman Instruments, Fullerton, Calif.) cocktail. Water samples were counted with 89 percent efficiency.

The biomass was scraped from the slide used for light incubation. The algae and water for each light and dark incubation were transferred to individual 50 ml plastic test tubes and centrifuged at 12,000 x gravity for 10 minutes at 4°C. The pellet was resuspended in 0.1 M phosphate buffer (pH 7.0) and brought to a final volume of 5 ml after which it was homogenized briefly with a teflon homogenizing pestle driven by a stirring motor. Five 0.25 ml amounts were removed, membrane filtered at 0.5 atmospheric pressure, and washed with successive rinses of distilled water. The filters were air dried, exposed to fumes of concentrated HCl to remove any adsorbed radioactivity. Incorporated radioactivity was determined by liquid scintillation counting after combusting the samples in a sample oxidizer (Packard Instruments, Naperville, Ill.) and collecting the $^{14}CO_2$ from combustion as a carbamate compound. These samples were counted with 62 percent efficiency.

Five 0.5 ml aliquots from each homogenized community were transferred to test tubes and 7.0 ml acetone (made basic with the addition of a pinch of $CaCO_3$) was added. The chlorophyll $_a$ content was determined after overnight extraction at refrigerated temperatures. The samples were centrifuged to pelletize the algal cells and the chlorophyll $_a$ was determined from optical density readings before and after acidification to correct for phaeophytin content according to the method of Lorenzen[21].

Experiments with vanadium and nickel were conducted as follows: A portion of the biomass on each slide was removed and homogenized briefly in a small volume of water from that test system. A small volume (0.2-0.5 ml) was transferred to a vial (5 ml capacity) and 4.0 ml water from the test system was added. Isotope was added to provide a final concentration of 0.05 uCi ml^{-1}. Duplicate or triplicate samples were incubated exposed to light and a single vial was covered with aluminum foil to provide a measure of dark adsorption. All incubations were again conducted under ambient light and temperature conditions for two hours about solar noon.

Incorporation was stopped with the addition of 0.2 ml formaldehyde after which the algae were recovered by membrane filtration and the filters treated as described. The filtrate was treated as described above and chlorophyll determinations were made as described but using 0.2 ml aliquots and without phaeophytin correction.

Data Processing

The values for the five replicate chlorophyll $_a$ determinations for each light or dark incubation were averaged and reported as ug chlorophyll $_a$ for the algae on one side of a slide. Similarly, the DPM ^{14}C incorporated for the five replicate filtered subsamples were averaged for each incubation. Considerable variability in raw data was generally encountered. The standard deviation was greater when the mean was low. The DPM excreted were determined. The value for incorporated radioactivity was normalized by dividing by ug chlorophyll $_a$. The normalized value for each dark incubation was subtracted from the normalized data for each corresponding light incubation to correct for adsorbed radioactivity. The proportion of ^{14}C excreted ($\frac{^{14}C \text{ excreted}}{^{14}C \text{ incorporated} + {}^{14}C \text{ excreted}}$) was determined and the ratio was used to adjust the dark bottle corrected data for excreted carbon.

ALGAL PIGMENT EXTRACTION

Chlorophylls

Extraction -

One-third of one side of each slide was scraped into an aluminum foil dish. Adhering water was removed by absorbing it onto a wick made from a piece of Whatman #3 filter paper.

The residues were transferred to 25 or 50 ml flasks, and extracted with 4.0 ml of 80 percent dimethylsulfoxide (DMSO) with shaking on the wrist-action shaker. The yellowish extract was filtered slowly (no more than two inches of mercury on the vacuum pump dial) through paper into side-arm test tubes. The tube funnel was angled so that no solution went into the vacuum line. An attempt was made to try to get as much as possible of the algal suspension on the filter paper and avoid spilling it around the edges. Pasteur pipets and spatulas were used to get out the last traces of material (Seely, Duncan, and Vidaver[22]).

The filtrate in the filter tubes was saved (stoppered) for later analysis on the Beckman spectrophotometer as this extract contained most of the chlorophyll $_c$ (which is produced only by diatoms).

The residue on the paper was extracted as before with 4.0 ml of acetone, and shaken (paper and all) for fifteen minutes on the shaker in stoppered flasks. The stoppers were covered with aluminum foil.

The samples were filtered as before, using a weak vacuum, being careful not to leave the tube under the vacuum any longer than necessary to keep down loss of acetone. The green extract was reserved in stoppered tubes for analysis of chlorophyll $_a$ (produced by all algae).

Analysis -

A Beckman DBGT spectrophotometer was used for chlorophyll $_c$ analysis at 570 and 630 nanometers (nm) with an 80 percent DMSO blank. The spectrum of each DMSO extract was run from 750 down to 550 nm, using the 0-1 A scale. The sample curvette was rinsed and dried with acetone between samples. The concentration of chlorophylls was computed (Jeffrey[23]).

The same procedure was used for the chlorophyll $_a$-rich extracts, except using acetone to zero initially. The concentration of chlorophyll $_a$ was computed using the previous equation.

The a/c ratio was determined by adding the two concentrations of chlorophyll $_a$ in the two extracts and dividing by the chlorophyll $_c$ concentration in the DMSO extract. A low ratio (8 or less) indicates a high proportion of diatoms; pure cultures of marine diatoms average a ratio of 4.

Phycocyanins

Extraction -

The algal community was scraped from one side of a slide as before. Excess water was removed and the cells were suspended in 8 ml of 0.005 M pH 6 phosphate buffer. The suspension was sonicated in a stirred ice bath in the dark to prevent photo-oxidation for 12 minutes, and centrifuged at 12,000 rpm for 15 minutes.

Column Chromatography -

The columns were prepared in 25 ml burets. A glass wool pad was put on the bottom and Bio-Gel HT hydroxyapatite added from a well-shaken suspension until the column was about 40 mm high. The column was then rinsed with 10 ml of 0.005 M phosphate buffer, then the sonicate was added using a Pasteur pipet, taking care to disturb the top of the column as little as possible. The sonicate was allowed to run through, using a slight vacuum; the solution was discarded. A new collection vessel was then used, 0.25 M phosphate buffer was carefully added, and the column was run until 7 to 9 ml of concentrated buffer had been collected or until all visible blue color was completely removed. The spectrum was run on this fraction (Swingle and Tiselius[24]).

Analysis -

The absorption spectrum was run on the Beckman from 750 to 500 nm. The 0-1 scale was used if much color was present; otherwise, the 10-millivolt recorder scale was used to enlarge the phycocyanin peak, which appeared at 620 nm.

The concentration of phycocyanin in mg/l (ug/ml) was determined by multiplying ($OD_{620}-OD_{750}$) by 129. Multiplying this figure by the number of ml collected gave the number of micrograms of phycocyanin on the area of the slide scraped originally (Troxler and Lester[25]).

Biomass Determinations

The growth from one side of a slide was carefully scraped and placed in a crucible weighed according to quantitative analytical procedures. It was then dried to constant weight at 103°C. The total solid weight was then determined. The crucible was then heated to 600°C and dried to constant weight in order to remove the volatile solids.

Extraction of Metals

The extraction of the metals accumulated in the algal biomass was carried out according to the methods described by Slavin[22]. The determinations were made using an atomic absorption spectrophotometer.

Introduction of Chemicals

The chemicals studied were: vanadium as vanadium chloride, chromate as potassium dichromate, selenate as sodium selenate, selenite as selenious acid, boron as boric acid, nickel as nickel nitrate, and rubidium as rubidium carbonate.

SECTION VI

DISCUSSION OF RESULTS

These experiments were carried out under as near natural conditions as possible and at various seasons of the year in order to determine the effects of various metals on the algal composition of natural communities. Particular interest was in the question as to how various kinds and amounts of these metals might affect shifts in species composition of diatom-dominated communities.

In order to determine how variations in natural conditions might influence the effects of a given metal, these experiments were carried out at different times of the year. An effort was made to keep all chemical and physical characteristics of the water in similar concentrations or quantities in all test boxes except for the chemical being tested. In order to do this the various characteristics were frequently monitored. Temperature and pH were in most cases continually monitored.

It was realized that no one has been able to keep a highly species-diversified flora of diatoms in synthetic water more than about a week. Therefore, natural water was used and about 1.5 l/hr of new filtered natural water was added to all tests to supply unrecognized trace substances found in natural conditions.

VANADIUM

Vanadium experiments were carried out as follows: July 22-August 12, 1971; September 11-October 11, 1971; November 5-December 12, 1971; and

February 1-March 11, 1972.

The greatest background data differences in these experiments were in temperature and day length. The July-August and September-October temperatures were quite similar, averages varying from 14.2°C to 16.0°C. In the November-December experiments the temperatures were maintained higher, averages varying from 19.5°C to 21.27°C, and in February-March the averages varied from 18.61°C to 18.94°C. The average day lengths in the November-December experiments were 9 hours and 47 minutes, and in the February-March experiments, 10 hours and 55 minutes. The July-August experiments had an average day length of 14 hours and 11 minutes, and the October-November experiments had an average day length of 11 hours and 59 minutes (Tables 23-48).

The chemical backgrounds of all experiments were quite similar except for the following differences. In the July-August experiments the calcium hardness was a little high in test #5. In the September-October experiments the average copper was a little high in tests #1 and #5. In the November-December experiments the sulfate was high in test #5, and the methyl orange alkalinity was very low. The zinc and copper were higher than in the other tests (Tables 39-40). Likewise, in test #6, the increase in sulfate and the lower concentration of methyl orange alkalinity is probably due to the use of sulfuric acid for controlling the pH within a narrow range. The greatest variation was seen in the February-March experiments (Tables 43-48). These were much longer experiments and therefore this might be a contributing factor.

In the July-August experiments the effects of the following average concentrations of vanadium were studied: 3.4 ug/l, 3.6 ug/l, 8.8 ug/l, 9.9 ug/l, 20.3 ug/l, and 20.7 ug/l.

Good diatom diversity was maintained at all concentrations. Melosira varians was the dominant diatom. Cocconeis placentula var. euglypta and Achnanthes lanceolata were also common. Blue-green algae were only of frequent occurrence and did not vary greatly. At 20.3 ug/l to 20.7 ug/l the diatom growth was a little less but the diversity was good (Table 1).

Because of the sloughing problem total weight was not very reliable, but there was a tendency for the volatile solids and total weights to be more in the vanadium-treated experiments than in the controls, indicating that vanadium improves slightly the total algal biomass and, in this case, diatom growth. There was not much difference between the various concentrations.

When one examines the accumulation of vanadium we see that the most rapid rates of accumulation are at the lowest concentrations. The greatest amount of accumulation is about 250 ug/gm (Pl. 1, Fig. 1). Observational data indicate there was a little increase in blue-green algae in the tests averaging 3.4 ug/l and 3.6 ug/l of vanadium. This is also borne out by the analysis for phycocyanin pigments which show a similar small increase at approximately 3 and 7 ug/l with a little less at 20 ug/l (Pl. 1, Fig. 2).

In the September-October experiments the concentrations of vanadium tested varied between an average of 8.7 ug/l and an average of 40.7 ug/l.

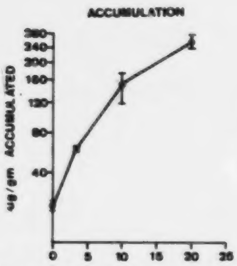

FIG. 1. VANADIUM µg/l IN WATER

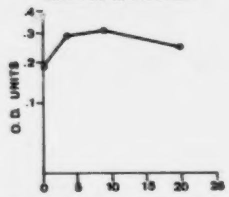

FIG. 2. VANADIUM µg/l IN WATER

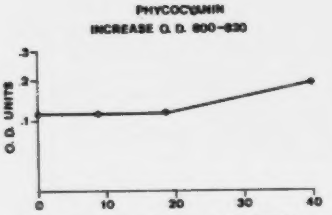

FIG. 3. VANADIUM AVERAGE µg/l IN WATER

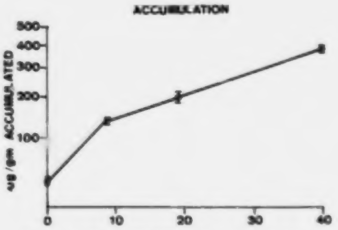

FIG. 4. VANADIUM AVERAGE µg/l IN WATER

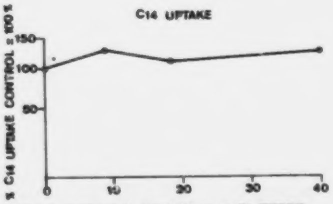

FIG. 5. VANADIUM AVERAGE µg/l IN WATER

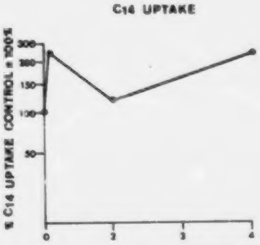

FIG. 7. VANADIUM mg/l IN WATER

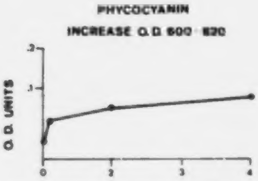

FIG. 6. VANADIUM mg/l IN WATER

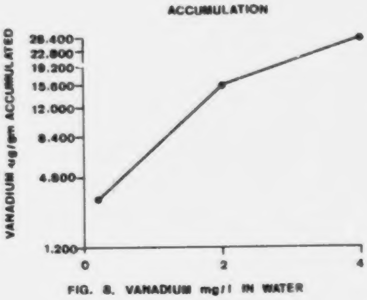

FIG. 8. VANADIUM mg/l IN WATER

Plate 1. Fig. 1 - Vanadium, accumulation µg/gm (July-Aug.); Fig. 2 - Vanadium, phycocyanin in optical density units (O.D.) (July-Aug.); Fig. 3 - Vanadium, phycocyanin in O.D. units (Sept.-Oct.); Fig. 4 - Vanadium, accumulation µg/gm (Sept.-Oct.); Fig. 5 - Vanadium, ^{14}C uptake - % of control (Sept.-Oct.); Fig. 6 - Vanadium, phycocyanin in O.D. units (Nov.-Dec.); Fig. 7 - Vanadium, ^{14}C uptake - % of control (Nov.-Dec.); Fig. 8 - Vanadium, accumulation µg/gm (Nov.-Dec.).

At the end of the experiments diatoms were still the dominant forms in the controls and the diversity was good. Melosira varians was the most common diatom with Cocconeis placentula var. euglypta and Achnanthes lanceolata also of common occurrence. Green algae were fairly rare and blue-green algae were frequent to common. This is also seen in the 8.7 to 9.1 ug/l experiments. At 18.4 to 20.1 ug/l the diatoms seemed to be a little less than in the previous experiment. However, according to the data the biomass was somewhat higher at this level. The green alga, Stigeoclonium, was more common at this level and the blue-greens were about the same. At 39.7 to 40 ug/l there was poor diatom diversity and poor growth. The green algae were rare to frequent, and the blue-green algae were common. This is supported by the phycocyanin analysis in which an increase in phycocyanin pigments occurred at the concentrations near 40 ug/l. The accumulation was similar but a little higher than that in the July-August experiments with the greatest increase with increased concentration being at the lower concentrations, particularly between the control and 8.7 to 9.1 ug/l (Pl. 1, Figs. 3, 4).

The ^{14}C uptake per ugm of chlorophyll $_a$ did not seem to vary much in any of the concentrations. It tended to be a little higher in those in which vanadium was present than in the control (Pl. 1, Fig. 5).

The November-December experiments were very similar in concentrations to those carried out in February-March (Tables 3, 31-42). Also the temperature of the water was quite similar, being 19.7°-21.3°C averaged in November-December, and 18°-19°C averaged in February-March. The main difference was in the day length, being a little over an hour longer in the February-March experiments. The concentrations of vanadium studied in the November-December experiments averaged as follows: 0.21 mg/l, 2.02 mg/l, and 4.07 mg/l.

The diatoms dominated the communities in the test concentrations and in the control at the beginning of the experiments. At an average of 0.21 mg/l and 2.02 mg/l of vanadium the diatom diversity was high and blue-greens were very frequent to common at the end of the experiment. Diatom growth was heavy. At 4.27 mg/l of vanadium the diatom growth was very poor at the end of the experiment, and blue-green algae were abundant.

This increase in blue-green algae in 4.07 mg/l vanadium was also seen in the pigment analyses. At this concentration the phycocyanin increased 5.6 times the increase in the controls during the course of the experiment (Pl. 1, Fig. 6). The absolute increase is small because of the low amount of biomass which was much less than in earlier experiments.

The ^{14}C uptake increased 251 percent of the control at 0.21 mg/l, then decreased at 2.02 mg/l, and then increased to 253 percent of the control at 4.07 mg/l of vanadium in the test water (Pl. 1, Fig. 7). There was a steady increase in accumulation of vanadium as the concentration in the test water increased, resulting in 25,800 ug/gm at 4.07 mg/l in the water (Pl. 1, Fig. 8). This much higher accumulation in these experiments is related to the concentration in the external medium and the less dilution by cell division.

The control in the February-March experiments maintained a good diatom diversity with some greens, particularly Ulothrix zonata and Stigeoclonium lubricum, being present to frequent and blue-green algae being fairly rare. At 2 mg/l there was good diatom diversity, the green algae were common with Ulothrix zonata and Stigeoclonium lubricum being the most common forms, and the blue-green algae varied from rare to very frequent. The most common diatoms were Synedra sp. 1 and Achnanthes lanceolata, with Cymbella sp. and Odontidium vulgaris of frequent occurrence. At 4.87 mg/l the diatoms were in fairly poor condition, the blue-green algae were extremely common, and the green algae--probably Ulothrix--were common. Thus we see a decided shift, as in previous experiments, in the kinds of algae dominant at these various concentrations, blue-greens being the dominant algae at 4 mg/l. This was also borne out by the phycocyanin pigment experiments which showed that there were many more blue-greens present at 4 mg/l than in the control (Table 4; Pl. 2, Fig. 1).

We find that ^{14}C uptake was highest in the control and lowest at about 4.87 mg/l. At this concentration the accumulation of vanadium was 18,200 ug/gm which is less than that accumulated in November-December at a similar concentration. This may be due to biological dilution as the algae were growing faster at this date. The somewhat toxic effect as evidenced by the reduction in ^{14}C uptake seems to be more severe when the cells of blue-green algae are dividing more rapidly (Pl. 2, Figs. 2, 3).

CHROMIUM

Four series of chromium experiments were carried out during the periods March 27-April 27, 1972; May 10-May 26, 1972; July 30-July 21, 1972; and July 28-August 17, 1972 (Tables 49-69).

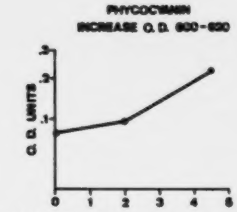

FIG. 1. VANADIUM mg/l IN WATER

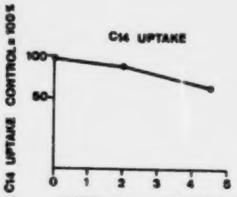

FIG. 2.

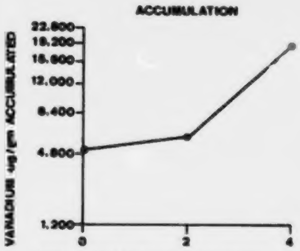

FIG. 3. VANADIUM mg/l IN WATER

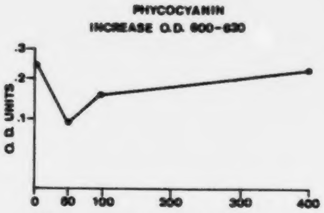

FIG. 4. CHROMIUM µg/l IN WATER

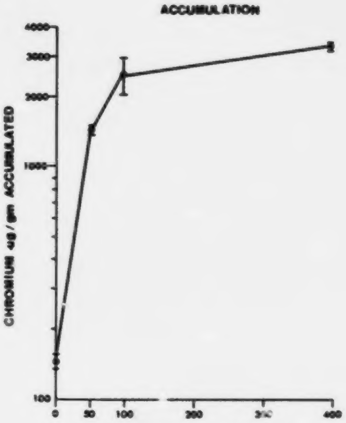

FIG. 5. CHROMIUM µg/l IN WATER

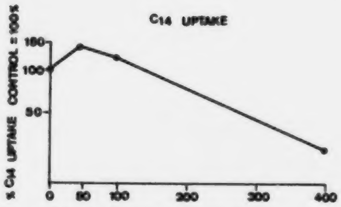

FIG. 6. CHROMIUM µg/l IN WATER

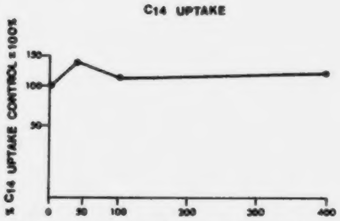

FIG. 7. CHROMIUM AVERAGE µg/l IN WATER

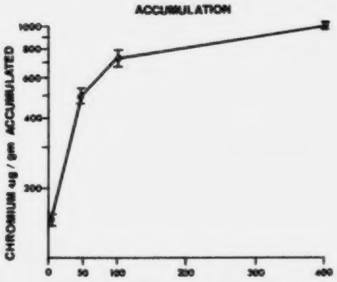

FIG. 8. CHROMIUM AVERAGE µg/l IN WATER

Plate 2. Fig. 1 - Vanadium, phycocyanin in O.D. units (Feb.-Mar.); Fig. 2 - Vanadium, ^{14}C uptake - % of control (Feb.-Mar.); Fig. 3 - Vanadium, accumulation µg/gm (Feb.-Mar.); Fig. 4 - Chromium, phycocyanin in O.D. units (Mar.-Apr.); Fig. 5 - Chromium, accumulation µg/gm (Mar.-Apr.); Fig. 6 - Chromium, ^{14}C uptake - % of control (Mar.-Apr.); Fig. 7 - Chromium, ^{14}C uptake - % of control (May); Fig. 8 - Chromium, accumulation µg/gm (May).

In the first two series a number of different concentrations were studied, whereas in the last two studies a control and an average of about 0.4 mg/l chromium were studied as this was the concentration determined in the earlier experiments to cause the greatest shift in the structure of the algal communities. The results of these last two series of experiments are discussed but figures are not given.

The temperatures in these experiments varied. In the March-April experiments the temperature averaged about 21°C. This was due to the fact that the cooling coils had not been placed within the experimental containers as it was not thought to be necessary because the temperature was in the optimum range for diatom growth. In the May, June-July, and July-August experiments the temperature ranged from 15.9°-18°C. The last three experiments were also quite similar in day lengths (less than 1 hour difference) whereas the March-April experiment differed by an hour to 1 hour and 42 minutes. The averaged temperature in the latter experiments was that of the stream as the experiments were cooled by free-flowing stream water.

The background chemical and physical characteristics of the water were very similar in all of the experiments. In the March-April experiments, the silica averaged lower than is characteristic of the other series of experiments but at all times was in excess of that known to be necessary for diatom growth. Manganese averaged a little lower in the June-July experiments (Tables 49-69).

In the controls of the March-April experiments, diatoms remained common throughout the experiments (Table 5), and the blue-greens increased from rare to frequent during the course of the experiment. At 49-50 ug/l the diatoms were dominant throughout the experiment. The blue-greens varied from frequent to rare and the green algae Ulothrix and Stigeoclonium were sporadic in their occurrence, tending to disappear toward the end of the experiment. At concentrations of 95 and 97 ug/l diatoms remained dominant throughout the experiment although the diversity decreased considerably. Stigeoclonium lubricum increased from present to common during the course of the experiment. In the 97 ug/l concentration Ankistrodesmus became abundant during the course of the experiment as noted on April 22nd, but was not noted at the end of the experiment on April 26th. Blue-greens were frequent in both of the tests toward the end of the experiments. In the concentrations 396-397 ug/l most of the diatoms were dead after ten days of exposure to this concentration of chromium. The green alga, Stigeoclonium lubricum, became abundant and then became very rare, and Selastrum bibraeanum became common at the end of the experiment. The blue-greens Microcoleus vaginatus, Arthrospira jenneri, and Schizothrix calcicola became abundant in both boxes. The accumulation of chromium in the biomass shows the greatest increase with increased concentrations in the water in the lower concentrations--that is, at concentrations averaging from 49 to 97 ug/l. The increased accumulation between 97 and 397 ug/l in the water was not proportional to the increase in concentration (Pl. 2, Fig. 5).

The uptake of ^{14}C by the algae at approximately 50 ug/l concentration in water increased when compared with the control, and at 97 ug/l it was somewhat higher than the control but less than at 50 ug/l, whereas there was a great decrease in ^{14}C uptake in concentrations of 396-397 ug/l. It would appear that the greatest ^{14}C uptake occurred in algae that had accumulated about 1460 ugm of chromium per gram of biomass. At an average of 2500 ug/gm (95-97 ug/l) chromium the uptake was better than in the control but not as good as when the accumulation was approximately 1450 ug/gm. At 396-397 ug/l the high accumulation of chromium (3360 ug/gm) seemed to be decreasing uptake (Pl. 2, Fig. 6).

The pigment extraction experiments indicate that the algae at 396-397 ug/l concentrations were about like those in the control. However, an examination of the slides indicate that the blue-green algae were much more abundant than in the control. The reason for this difference is probably due to the fact that most of the blue-green algae at 396-397 ug/l were *Schizothrix calcicola* which had very narrow filaments (about 3 microns in diameter), whereas in the control larger filaments of *Microcoleus vaginatus* and *Arthrospira jenneri* were of only frequent occurrence. The larger celled algae have more pigment in them per cell than the very small algae. It should also be noted that an error in the extraction process may have occurred in the earlier experiments of this series, because the ability to isolate the phycocyanin and phycoerythin pigments from the chlorophyll was difficult. In the sonication of the cells to release the phycocyanin and phycoerythin some of the chlorophyll and its degradation products are released into the water. Dr. Larson developed a method for phycocyanin and phycoerythin extraction during the latter experiments and therefore these determinations are much more accurate (See Appendix).

In the May experiments, the concentrations tested were similar to those in March-April. The controlled tests had diatoms dominant throughout the experiments, blue-greens were rare, and the green algae were rare to frequent. They were Spirogyra sp., Oedogonium sp., Ulothrix zonata, and Stigeoclonium lubricum. At 49 ug/l diatoms were dominant throughout the experiments, Ulothrix zonata was of frequent occurrence, Oedogonium sp. was frequent, and Stigeoclonium lubricum was rare. At 100 ug/l diatoms were dominant throughout the experiment. However, the diversity decreased toward the end of the experiment. Stigeoclonium lubricum was of frequent to common occurrence, and blue-green algae were rare. At 403-407 ug/l, as in the March-April experiments, the diatoms were dead or in very poor condition at the end of the experiment, Stigeoclonium lubricum became common, and blue-greens were abundant. The dominant blue-green was Schizothrix calcicola which did not show by pigment extraction its great increase in this concentration when compared with the control. Again the difference was due to the difference in species of blue-greens that were present, a few filaments of the larger species occurring in the control and thus masking the abundance of Schizothrix calcicola (Table 6).

The accumulation of chromium in the biomass is not nearly as great in these experiments as in the March-April experiments. At approximately 50 ug/l concentration in the water the accumulation was 1450 ug/gm in the March-April experiments whereas in the May experiments it was roughly 500 ug/gm. A similar difference is seen at approximately 100 ug/l of chromium in the water. In May at 400 ug/l of chromium the accumulation was about 900 ug/gm whereas in the March-April experiments it was 3,350. This may be due to the fact that the rate of cell division was less as indicated by less biomass which resulted in less biological dilution in the March-April than in the May experiments. Therefore the accumulation per cell and therefore per gram of biomass was not as great in the May experiments. Studies carried out by Harvey, _et al_.[27] at the Savannah River Plant on radioactive metals has shown that biological dilution can have this effect of reducing the accumulation of the metal per cell or per gram of biomass (Pl. 2, Fig. 8).

A decrease in ^{14}C uptake was not pronounced at 400 ug/l of water as it was in the March-April experiments. This is no doubt correlated with the fact that the uptake per cell was not as great and therefore the deleterious effect would not have been as pronounced. However, the same pattern of ^{14}C uptake is present in both experiments, the greatest uptake being about 50 ug/l of chromium in the water (Pl.2, Fig. 7).

In the June-July series of experiments one range of concentrations of chromium was tested--that is, from 380 to 398 ug/l. A shift to blue-green algae was not as great in this series as in the previous series of experiments at similar concentrations. The background chemistry was very similar to that of the two previous series of experiments (Table 7).

The difference in the development of blue-green algae can be explained by the lower accumulation of chromium (average 645 ug/gm). The amount of accumulation was less than in the 50 ug/l tests in March-April, and between 50 and 100 ug/l in the tests in May. At these amounts of accumulation a pronounced blue-green algal flora was not present in the two previous series of experiments. Furthermore, we find that the ^{14}C uptake (132%) is more similar to that found between 40 and 100 ug/l in the March-April and May experiments. Thus we see very good correlation between the amount of accumulation of chromium per gram of biomass, the ^{14}C uptake, and the development of a blue-green algal flora. It is difficult to explain why there was a lower accumulation of chromium at this concentration during these experiments. Nevertheless, as stated above, the fact that there was a low accumulation did produce results similar to those found in previous experiments in which the accumulation was similar.

In the July-August test of 400 ug/l of chromium in water there was an accumulation of chromium of 2,000 ug/gm of biomass. This is less than the accumulation at this concentration in the March-April experiments but more than the accumulation in the May experiments. It is over three times as much as the accumulation that occurred in the June-July experiments.

In this concentration blue-green algae were dominant (Table 8, Pl. 3). The diatoms were mostly dead. The background chemical data are given in Table 68. Only one test on one concentration was carried out, because the test was to confirm the conditions found at this concentration in earlier experiments. However, the biomass seemed to be much less than that of the previous experiments. In the previous experiments the bio-

Plate 3. Chromium 0.4 mg/l. Blue-green algae, Microcoleus vaginatus, dominating flora.

mass in the various concentrations seemed to be a little greater than that of the control, although this is often not significant and, as stated previously, biomass determinations are very unreliable because of the sloughing of the algae. The anomaly of this experiment is that the ^{14}C uptake was 216 percent that of the control. This is far higher than the uptake that might be predicted from previous experiments. Whether this is an experimental error or occurred for some unknown reason, one cannot be certain.

In conclusion the results of these experiments clearly indicate that at approximately 400 ug/l chromium the diatom flora is almost--if not completely--destroyed and that blue-green algae become dominant. The degree to which the blue-green algae become dominant and the diatoms are adversely affected seems to be correlated with the accumulation of chromium in the biomass--that is, the ug/gm of biomass. In all except the last experiment the ^{14}C uptake could also be correlated with the accumulation.

The general chemical background of the last experiment was not significantly different in any respect from that of previous experiments, and the day length was intermittent between that found in the earlier experiments. Thus there is no obvious reason for this difference in uptake.

SELENIUM

Four series of selenium experiments have been carried out. The first two experiments were carried out between September 20 and October 20, 1972, and November 9 and December 4, 1972. In these series of experiments selenite (H_2SeO_3) was the source of selenium studied. In 1973 two other series of selenium experiments were carried out from April 3 to May 11, 1973, and June 15 to July 3, 1973. In this second series selenium as selenite (H_2SeO_3) and selenate (Na_2SeO_4) were studied.

In the September-October experiments seven concentrations of selenium as selenite were tested. These ranged, as seen in Tables 70-77, from 0.1 mg/l to 40.8 mg/l. In the November-December experiments, 1, 10, and 40.3-40.9 mg/l were studied. There were only three concentrations in the September-October experiments that are comparable with those in November-December (Tables 78-85).

When one examines the tables it is quite evident that the background chemistry for these experiments was quite similar. The greatest differences were in temperature, being about 6°C higher in the September-October experiments. Likewise, the day length was quite different, being 1 hour and 47 minutes longer in September-October than in November-December.

The trace metal chemistry was quite similar except that zinc was high the two times it was tested in the November-December experiments. Whether this was typical of the whole experiment one cannot tell. Both times it was tested it ranged from 1.5 to over 3 ppm. This might interfere with the growth of some of the algae, but it does not seem to do so. Iron tended to be higher in the November-December experiments.

In the September-October experiments the diatom growth was excellent and the diversity was high in concentrations from 0.1 mg/l to 10.6 mg/l of selenium as selenite. At 10.6 mg/l the diatom growth was heavy, and diversity was good; whereas at 20.9 mg/l and 40.8 mg/l the growth was heavy but the diatom diversity was less. The volatile biomass determinations also support these observations. In the control and 0.1 mg/l selenium the green algae were frequent and the blue-green algae were rare. At 1.04 mg/l the blue-green algae became more frequent and the green algae remained frequent. This was also the case at 2.6 mg/l. At 5.4 and 10.6 mg/l the green algae were frequent but the blue-green algae were rare. At 20.9 mg/l the green algae were rare and at 40.8 mg/l no blue-green or green algae were present (Table 9).

Thus it is apparent that as the selenium concentration increased the diatom growth was heavy, being heaviest at 10 to 40.8 mg/l. However, the diversity decreased at the higher concentrations. The green and blue-green algae likewise decreased at the higher concentrations.

The chlorophyll $_{a/c}$ ratios were similar throughout all experiments, indicating the similar proportions of the communities being diatoms (Pl.4, Fig. 2).

The data showed a decided decrease in ^{14}C uptake above 5 mg/l (Pl. 4, Fig. 1). This is very interesting in view of the fact that there was a heavy diatom population on the slides. For some reason it would appear that the diatoms were not photosynthesizing very well. Perhaps there

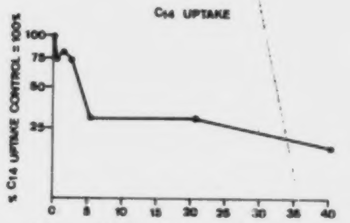

FIG. 1. SELENITE (Se) mg/l IN WATER

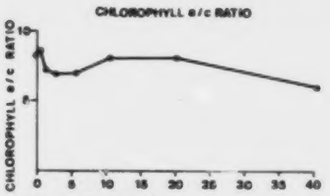

FIG. 2. SELENITE (Se) mg/l IN WATER

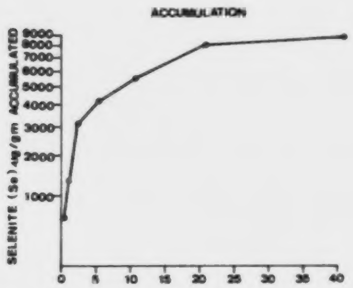

FIG. 3. SELENITE (Se) mg/l IN WATER

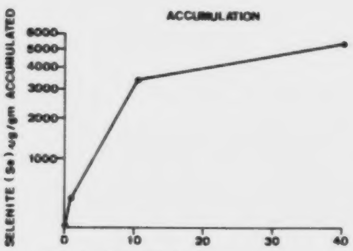

FIG. 4. SELENITE (Se) mg/l IN WATER

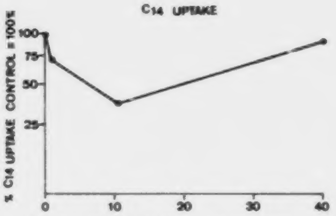

FIG. 5. SELENITE (Se) mg/l IN WATER

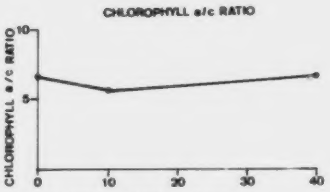

FIG. 6. SELENITE (Se) mg/l IN WATER

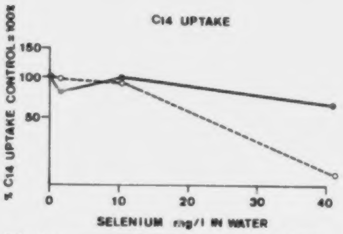

FIG. 7. ●—— SELENITE ○------ SELENATE

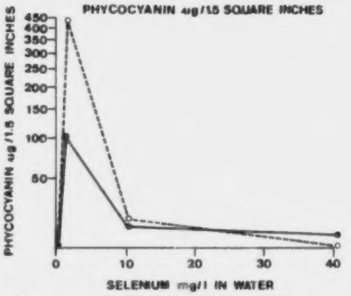

FIG. 8. ●—— SELENITE ○------ SELENATE

Plate 4. Fig. 1 - Selenium, ^{14}C uptake - % of control (Sept.-Oct.); Fig. 2 - Selenium, chlorophyll a/c ratio (Sept.-Oct.); Fig. 3 - Selenium, accumulation µg/gm (Sept.-Oct.); Fig. 4 - Selenium, accumulation µg/gm (Nov.-Dec.); Fig. 5 - Selenium, ^{14}C uptake - % of control (Nov.-Dec.); Fig. 6 - Selenium, chlorophyll a/c ratio (Nov.-Dec.); Fig. 7 - Selenium, ^{14}C uptake - % of control (Apr.-May); Fig. 8 - Selenium, phycocyanin µg/1.5 sq. inches (Apr. - May).

was a shading effect due to the extremely heavy growth. The accumulation of the selenium in the cells is correlated with the drop in ^{14}C uptake when the accumulation reaches about 40.8 mg/l (Pl. 4, Fig. 3). Thus it may be that it is the accumulation of the selenium rather than shading that is hindering the ^{14}C uptake. The heavy growth of diatoms would indicate that this amount of uptake of selenium is not interfering with cell division at the higher concentrations. Very little pigment of blue-green algae was noted and was not recorded.

In the November-December experiments, the zinc and chlorides were quite high. However, this apparently did not interfere with diatom growth because there is good diversity and fairly heavy growth in the control. There was heavy growth and good diversity at 1 mg/l selenite and also at 10.3 to 10.4 mg/l selenite. At 40 mg/l the diatom diversity was greatly reduced and the biomass was not as much. Blue-green algae never became common or reached a frequency above rare in these experiments. The green algae were frequent at 1 mg/l selenium and in one of the concentrations of 10 mg/l of selenium. Otherwise the green algae were rare (Table 10).

An examination of the accumulation of selenium shows that it was much less than in the September-October experiments. In September-October at 10 mg/l about 5600 ug/gm were accumulated, whereas at the same concentration in November-December about 3200 ug/gm were accumulated (Pl. 4, Fig. 4).

As in the September-October experiments, we find a decided dip in ^{14}C uptake around 5 to 10 mg/l of selenite in the water (Pl. 4, Fig. 5). However, instead of a reduction at 40 mg/l we find that the ^{14}C uptake at 40 mg/l was almost equal to that of the control. This again may be due to the difference in accumulation of selenium which was a little over 5200 ug/gm in November-December at 40 mg/l in the test water whereas in the September-October experiments it was 8,800 ug/gm.

The chlorophyll $_{a/c}$ ratio remained quite similar throughout the experiment indicating that the ratio of diatoms to other algae was quite similar throughout all experiments (Pl. 4, Fig. 6).

In the spring and summer experiments the effects of selenium of average concentrations of 1.1 to 1.2 mg/l, 10.4 to 10.6 mg/l, and 40.5 to 41.5 mg/l were studied. Detailed background chemical analyses are given in Tables 86-99. The main differences in these two series of experiments in April-May and June-July was in the day length, the average day length differing by 1 hour and 27 minutes, and the temperature differing by an average of 7.2°C. There were also occasional differences in concentrations of alkalinity, of chlorides, and very occasionally of phosphates; however, the differences were usually not very great and only very occasionally was the average different in similar concentrations of selenium in the two sets of experiments. In the April-May experiments phenolphthalein alkalinity was present in the control and at concentrations of 1 mg/l of selenite. Otherwise phenolphthalein alkalinity was not recorded in this experiment.

During both series of experiments observations of kinds of algae and their relative abundance were made at the beginning, near the middle, and at the end of the experiments. These are recorded in Tables 11 and 12. It is apparent that in both series of experiments in which selenium was introduced as selenate very little, if any, algal growth occurred in concentrations of 40 mg/l. There were a very few blue-green algae present in the July experiments.

The diatoms in both the April-May and June-July experiments were in very poor condition or not living in concentrations of 10 mg/l of selenium as selenate. In both series of experiments at concentrations of 10 mg/l of selenium as selenate blue-green algae varied from common to very common, and the most common blue-green was Schizothrix calcicola. At 1 mg/l selenate the diatoms were not in good condition, the green alga Stigeoclonium was common, and blue-green algae were fairly common.

In contrast, at 40 mg/l of selenite (H_2SeO_3) the diatoms were in good condition in July and fair condition in May; the green algae were more common in May than in July. The blue-green alga Schizothrix calcicola was present in May but was not recorded in July.

In test waters averaging about 10 mg/l diatom diversity was poor in May with Cocconeis placentula var. euglypta being the most common species. Diatoms were common although the diversity was poor at this concentration. In June-July the diatom diversity was well developed. In May the green alga Stigeoclonium lubricum (?) was common and Draparnaldia plumosa was frequent in May. The blue-green alga Schizothrix calcicola was frequent to common. In July the green algae were not as common with Cosmarium sp. the only frequent green algae. Schizothrix calcicola occurred in patches, but was only frequent in occurrence.

At 1 mg/l of selenite the diatom growth was good in both May and July. However, in May the diversity was restricted. A few species such as Achnanthes lanceolata were common. In both experiments the green algae were frequent to common. In May the blue-green algae were more common than they were in July. Controls in both cases maintained good diatom diversity throughout the experiments, although in May there was a little more green than blue-green algae present.

Thus we see the same trend of conditions in both series--that is, at 40 mg/l of selenate nothing could grow, and that selenate was generally less favorable to diatoms than selenite. In contrast, the blue-green algae did very well at both 1 and 10 mg/l of selenate.

Although total biomass is not a very reliable measure because of the loss of the algae due to handling in the course of the experiment, it was quite evident that there was a tendency for greater diatom biomass to develop at 1 mg/l selenite than at other concentrations.

When one examines the pigment analyses (Pl. 4, Fig. 8; Pl. 5, Fig. 1), it is very evident in both series of experiments that the blue-green

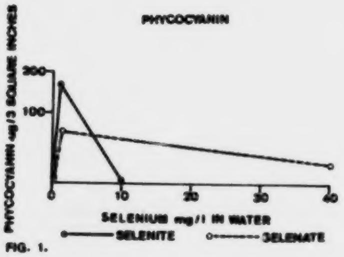

FIG. 1.

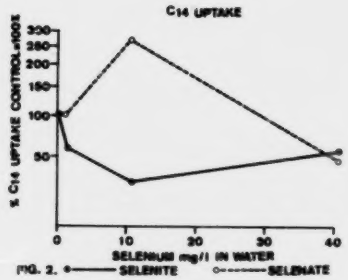

FIG. 2.

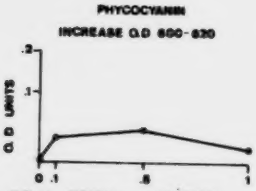

FIG. 3.

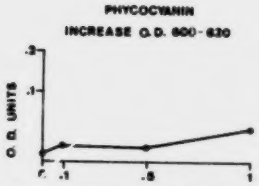

FIG. 4.

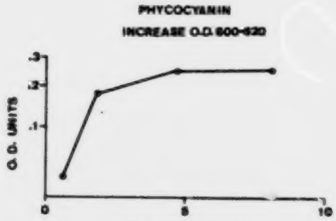

FIG. 5.

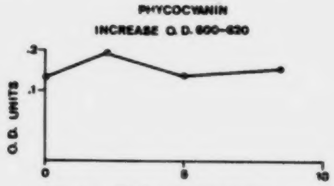

FIG. 6.

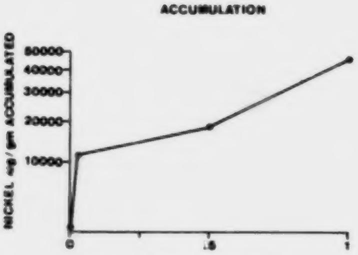

FIG. 8.

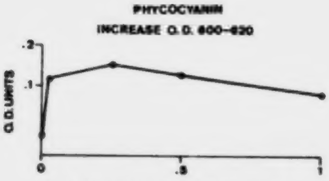

FIG. 7.

Plate 5. Fig. 1 - Selenium, phycocyanin µg/3 sq. inches (June-July); Fig. 2 - Selenium, ^{14}C uptake - % of control (June-July); Fig. 3 - Boron, phycocyanin in O.D. units (Sept.-Nov.); Fig. 4 - Boron, phycocyanin in O.D. units (June-Aug.); Fig. 5 - Nickel, phycocyanin in O.D. units (Mar.-Apr.); Fig. 6 - Nickel, phycocyanin in O.D. units (May-June); Fig. 7 - Nickel, phycocyanin in O.D. units (Nov.-Dec.); Fig. 8 - Nickel, accumulation µg/gm (Nov.-Dec.).

algae were more common in 1 mg/l of selenate and selenite than at higher concentrations. It is also very evident that the blue-green algae were usually about four times as common in the selenate experiments than in the selenite experiments in May at this concentration.

A definite decrease in blue-green algae in both selenate and selenite occurred at 10 mg/l in the May and in the selenate experiments in July as evidenced by the phycocyanin analyses (Pl. 4, Fig. 8; Pl. 5, Fig. 1). There was no phycocyanin analyses for selenite at 10 mg/l in July; however, the observational data indicate that in May and July Schizothrix calcicola was quite common at 10 mg/l selenate concentrations. The reason for this discrepancy in the selenate experiments is probably because this is an extremely small species and a great many filaments would be necessary to produce a small amount of phycocyanin. In contrast, we did not see many blue-green algae present in the selenite experiments at this concentration. The phycocyanin extraction experiments conform with the observations at 40 mg/l of selenate and selenite.

The ^{14}C uptake experiments in May indicate that the ^{14}C uptake was quite similar for selenate and selenite at 1 and 10 mg/l, although the kinds of algae, as seen by Tables 11 and 12, were somewhat different (Pl. 4, Fig. 7). In the selenite experiments there were more greens present than in the selenate at 10 mg/l. At 40 mg/l in the selenite experiments the diatoms were the main species and the uptake was less than at 10 mg/l. No algae were in 40 mg/l of selenate and therefore there was no uptake.

In July the ^{14}C uptake results were very different for selenate and selenite. Most of the uptake was by blue-green algae in the selenate experiments and by diatoms in the selenite experiments (Pl. 5, Fig. 2). At 10 mg/l we see that there was much greater ^{14}C uptake in the selenate experiments than in the selenite. This is probably due to the difference in the physiological conditions and in the amount and kinds of algae taking up the ^{14}C.

In the selenite experiments, at 40 mg/l the diatoms showed good health and a fair amount of uptake, which was a little higher than at 10 mg/l. In the selenate experiments there were fewer blue-green algae and much less uptake occurred at 40 mg/l than at 10 mg/l. The amounts of uptake in the selenite and selenate experiments were similar at 40 mg/l, but were carried out by different kinds of algae (Table 12).

From these selenium experiments the data indicate that concentrations of 1 mg/l and 10 mg/l of selenite stimulated diatom reproduction, and at 40 mg/l fair to good diatom growth occurred. In contrast, selenate at all concentrations was deleterious to diatom growth. Selenate was more favorable to the growth of blue-green algae than was selenite.

These experiments support the findings of Kumar and Prakash[17] which point out that selenate is more supportive of blue-green algal growth than selenite.

During these experiments a fair amount of sulfur was always present. This probably allowed for better growth in both the selenate and selenite experiments.

In the cells, about a third of the selenium was extractable by 70 percent methanol; most of this was selenite. There was no evidence for free or combined selenoamino acids. Most of the nonextractable selenium was probably associated with protein via selenotrisulfides.

BORON

Five series of boron experiments were performed. Three series were carried out between May 20-June 13, 1970; June 26-August 7, 1970; and September 23-November 4, 1970. The concentrations studied were approximately 0.03, 0.13, 0.5, and 1,0 mg/l of boron in solution. The December 15-February 9, 1971, experiments only studied the effects of an average of 2.02 mg/l of boron, and the July 20-August 20, 1973, experiments studied the effects of 1.1 mg/l of boron.

The day lengths of these experiments were quite variable (Tables 100-116). The longest day lengths were in the May-June experiments, being 14 hours and 46 minutes. The shortest day lengths were in the December-February experiments, being 9 hours and 43 minutes. Likewise the temperature varied considerably during these experiments, the coolest temperature being the early winter experiments with an average of 15.3°C, and the highest temperature being the June-August experiments averaging 23.3°C.

The general background chemistry (Tables 100-116) showed that the concentrations of various chemicals were quite similar throughout the whole series; however, there was some variation. In the May-June experiments phenolphthalein alkalinity was present which is typically not found in the stream water supplying these experiments. Likewise the methyl orange alkalinity was a little high. In the December-February experiments the phosphorus average was a little high as compared with the other experiments. In the June-August experiments the methyl orange alkalinity was a little high. In the July-August experiment silica was a little low, but never low enough to affect the size of populations of diatoms.

The biomass in the May-June experiments was a little higher than those found in the other experiments. In general, the structure of the algal communities was similar in the various concentrations of boron. In the May-June experiments in the control, diatoms dominated the community and the diversity was good. The most common genera were Cymbella, Navicula, and Synedra. The greens were similar in their commonness throughout the experiment. Blue-green algae became common in spots, but had an overall frequency occurrence during the middle of the experiment, becoming rare toward the end. In the 0.15 mg/l concentrations, the blue-greens increased in commonness, ranging from frequent at the beginning of the experiment to very common at the end. Diatoms remained dominant throughout the experiment and the common genera were as in the control. In the 0.52 mg/l experiment diatoms dominated throughout the experiment and were similar to the control. Blue-greens were common toward the end of the experiment, but since they were quite common at the beginning, not very much shift in their abundance was noted (Table 13).

In the 1.07 mg/l, blue-green algae were not noted at the beginning of the experiment whereas they became abundant at the end of the experiment. Stigeoclonium lubricum varied in abundance during the experiments. The diatoms were dominant at the beginning of the experiment and at the middle of the experiment, but were in poor condition by the end of the experiment. In these early experiments phycocyanin extraction was not carried out.

In the June-August experiments, the same trend occurred--that is, the blue-greens decreased rather than increased in the controls and diatoms remained dominant with good diversity throughout the experiment. The most common diatoms were Melosira varians, Cocconeis placentula, and various species of Cymbella. At 0.118 mg/l the diatoms were dominant and diversity was good throughout the experiment. Blue-green algae increased, being very common to common toward the middle and end of the experiment. At 0.52 mg/l the diatoms were dominant but the growth was not as great as in the two previous concentrations. The diversity was good. The blue-greens were frequent at the beginning of the experiment, becoming very common toward the end of the experiment. At 1.05 mg/l diatom growth was fair throughout the experiment, decreasing toward the end of the experiment. Melosira varians was common. The green alga

Stigeoclonium lubricum was common or very common throughout the experiment. The unicellular blue-green algae were common at the beginning of the experiment and became very common at the end (Table 14). As seen in Pl. 5, Fig. 4, the phycocyanin as determined by extraction increased with increased concentration throughout the experiment, the highest amount of phycocyanin being in the 1.05 mg/l boron concentration.

In the September-November experiments we see the same types of changes as in the two previous sets of experiments. In the control the diatoms remained dominant and the diversity was good throughout the experiments. Melosira varians was very common and Cocconeis placentula var. euglypta and Achnanthes lanceolata were common. Spirogyra sp. became frequent to common during the course of the experiments and Scenedesmus sp. was very common during the period when observations were made on October 12. However, by November 2 it was not seen in the communities. Blue-green algae remained frequent throughout the experiment. At the 0.125 mg/l boron concentration, the diatom diversity was good in the beginning of the experiment but then gradually decreased as it did in the control toward the end of the experiment. The same diatom species were common to very common as noted in the control. As in the control, Scenedesmus sp. became abundant around October 12, but was apparently not present at the end of the experiment. Blue-green algae were common to very common in the middle of the experiment and fairly common at the end of the experiment. At 0.488 mg/l the diatoms were present throughout the experiment but their diversity decreased toward the end of the experiment. Again Scenedesmus sp. was very common around October 12 but not apparent in the community at the end of the experiment. The blue-green algae increased from fairly rare to abundant to very common at the end of the experiment. At the 1.04 mg/l concentration the diatoms were common but the diversity poor toward the end of the experiments. Cocconeis placentula var. euglypta was the most common diatom. Spirogyra sp. became very common toward the end of the experiment, and blue-green algae were abundant (Table 15).

The phycocyanin extraction data indicate a pattern of increase in blue-green algae at 0.13, 0.488, and 1.04 mg/l (Pl. 5, Fig. 3). The low amounts were due to poor extraction techniques. The highest concentration of phycocyanin was at 0.488 mg/l, and at 1.04 mg/l it was not as great as in the other two concentrations. This may be due to a difference in the abundance of filamentous and unicellular blue-green algae present. Both forms were present in both concentrations. It should be noted that the slight decrease at 1.04 mg/l concentration of boron was different from that found in the June-August experiments when there was a marked increase at 1.05 mg/l boron.

In the December-February experiments, only one concentration of boron was studied and that was at an average of 2.02 mg/l. The background chemistry is given in Tables 112-113.

Compared with the controls the phycocyanin extraction experiments indicate that about 5.8 times more phycocyanin was in the 2.03 mg/l test than in the control after the biomass is equated for the two experiments, thus indicating a decided increase in blue-green algae. Diatoms were present but were not diverse throughout the experiments.

In the July-August experiments only one concentration was examined and that was an average of 1.1 mg/l soluble boron in water (Tables 114-116).

As seen in Plate 6, the unicellular blue-green and filamentous blue-green algae became quite common; however, the diatom Achnanthes lanceolata was very common and in good condition throughout the experiments. Other diatoms were less healthy and the overall diversity was much less.

NICKEL

Five series of nickel experiments were performed: March 29-April 29, 1971; May 22-July 31, 1971; November 5-December 12, 1971; February 1-March 11, 1972; and July 20-August 20, 1973. The average temperature during the course of these experiments was quite similar, ranging from 16.22°C to 21.3°C. The lowest temperature was in the May-July experiments when the temperature was about 16°C and the highest temperature was in the November-December experiments when the average temperature was about 20°-21°C. This is because in summer months the temperature was maintained at ambient stream temperature through cooling coils. During the winter months it was desirable to maintain the temperature within a range favorable to diatom growth in order that the results of the experiments might not be altered due to this cause. Therefore the temperature in the November-December experiments were ambient greenhouse temperatures which were a little higher than summer stream temperatures but not significantly higher to make a real difference in the growth of the algal communities.

Figure 1. Control for boron experiments. Diatoms, Achnanthes lanceolata, dominating flora.

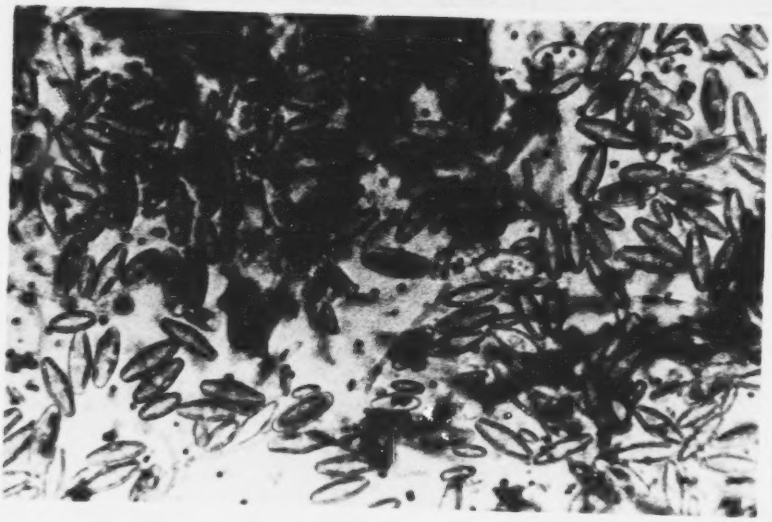

Figure 2. Boron, 1 mg/l. Unicellular glue-green algae dominating algal flora.

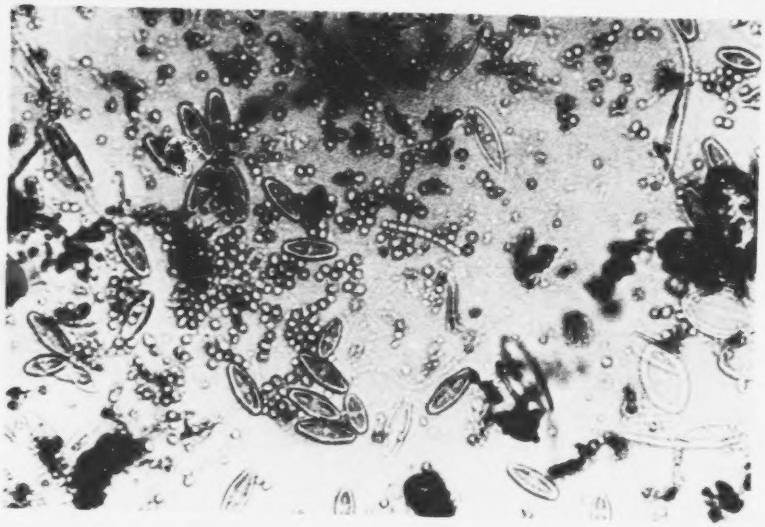

Figure 3. Boron, 1 mg/l. Blue-green algae, Schizothrix calcicola, dominating flora.

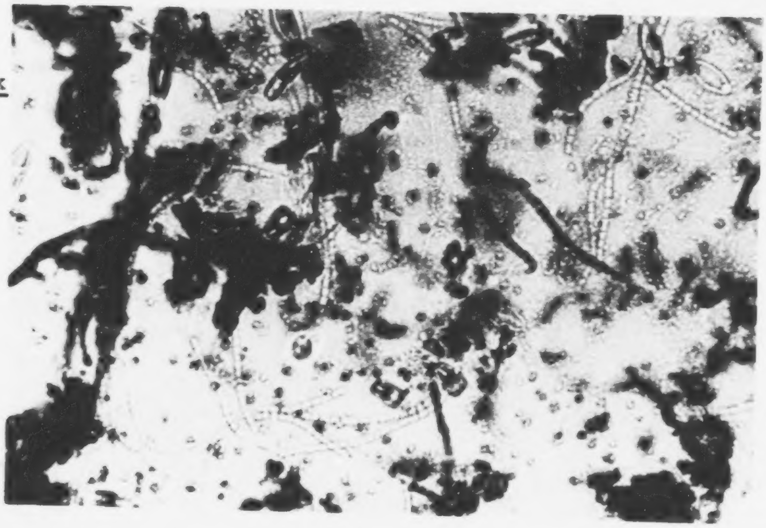

PLATE 6

Day lengths were quite variable; the shortest day length being 9 hours and 47 minutes in the November-December experiments and the longest ones being 14 hours and 52 minutes in the May-July experiments. The most similar day lengths in two separate series of experiments were those for May-July and July-August, which had an average difference of 46 minutes. The variance in day length undoubtedly had some affects on algal growth. However, part of the purpose of these experiments was to study the effect of nickel under natural varying daylight conditions. Most of the experiments ran from two to five weeks. The longest experiment was the May-July experiment which ran seven weeks (Tables 117-145).

The general background chemistry was quite similar in all experiments. In the March-April experiments the methyl orange alkalinity was a little low, and the sulfates were irregular, tending to be somewhat high. This was probably due to the use of sulfuric acid to adjust the pH at certain times. In the July-August experiments the silica was a little low, and the methyl orange alkalinity was a little higher than usual for the other experiments. In the February-March experiments the sulfates were quite variable, and the total hardness was a little high. This was also true for the November-December experiments. In general, the background chemistry during this series seemed to show more variability than in the other trace metal experiments. This is probably in part due to the fact that this was one of the first of the metals studied at very low concentions, and some technical difficulties were encountered in trying to keep the nickel constant. However, this does not explain all the variabilities which were natural for the periods in which the experiments were carried out. In no case was the variability highly significant nor did the extremes experienced in any one experiment not overlap those in other experiments.

In the March-April experiments the amounts of nickel tested ranged from an average of 2 to 8.6 ug/l. In the controls diatom diversity remained good throughout the experiment. Stigeoclonium was frequent in occurrence as were the green algae Ulothrix zonata and Spirogyra sp. Blue-green algae were of frequent occurrence. At 2-2.21 ug/l at the end of the experiment the diatom diversity was fair to poor, Stigeoclonium was common, Ulothrix zonata was frequent to common, and Spirogyra sp. was frequent. Blue-green algae varied from frequent to abundant at the end of the experiment. In the 4.54-4.78 ug/l of nickel the diatom diversity was poor, Ulothrix zonata was very common to abundant, and the blue-green algae were abundant. In the 7.6-8.6 ug/l experiment the diatoms were in very poor condition, Ulothrix zonata was common to abundant, Scenedesmus became common, and the blue-green algae were abundant (Table 16). These trends in blue-green algal production may also be seen in Pl. 5, Fig. 5, and show a decided increase between the control and 2 ug/l of nickel.

The phycocyanin concentration continued to increase but not in the same ratio with increased concentrations of nickel. The phycocyanin experiments support the observations that blue-green algae were very common at the higher concentrations of nickel.

In the May-July experiments similar concentrations were studied. They ranged from 2.2-9.1 ug/l. In the control the diatoms remained dominant and the diversity was good throughout the experiment. Various species of Synedra were dominant at the beginning of the experiment and Melosira varians replaced them in dominance toward the end. Blue-green algae were usually of rare occurrence and green algae were variable. In the tests of 2.2-2.3 ug/l of nickel blue-green algae became very common and the diatoms were of frequent occurrence,but the diversity became poor toward the end of the experiments. The most common were several species of Synedra, Achnanthes lanceolata, A. minutissima, Melosira varians, and Cymbella sp. In the 4.9-5.1 ug/l tests the diatoms decreased to frequent in occurrence but the diversity was poor. Blue-green algae were common. A similar condition resulted in the 8.1-9.1 ug/l test (Table 17; Pl. 5, Fig. 6).

This trend was also borne out by the phycocyanin experiments. However, it is interesting to note that in the March-April experiments blue-green algae continued to increase with higher concentrations whereas in this series the highest amount of blue-green pigment extracted occurred at 2.2-2.3 ug/l and then there was a slight decrease, indicating that the blue-green algae were not much greater than in the control. However the observations indicated that blue-green algae were very common in the 8.1-9.1 ug/l of nickel. This can probably be explained by the difference in algal species, the algae being the very small Schizothrix calcicola in the higher concentrations; however, part of the explanation may be due to the interference of other pigments. It was not until late

1972 that a more precise method for phycocyanin extraction was worked out.

The November-December experiments were carried out at much higher concentrations. The concentrations of nickel varied from 0.05-1.04 mg/l. In the controls the diatoms remained dominant and the diversity was very good throughout the experiments. The green alga, Stigeoclonium lubricum, was of rare occurrence, and blue-green algae were of frequent occurrence. At 0.05 mg/l diatom diversity was good throughout the experiment, Stigeoclonium lubricum and Spirogyra sp. were rare at the end of the experiment, and the blue-green algae were of frequent occurrence. At 0.5 mg/l of nickel the diatoms were very common and the diversity was poor, protonema of Stigeoclonium lubricum were of frequent occurrence, and unicellular blue-green algae were very common. At 1.04 mg/l the diversity of diatoms was usually very poor, but a single diatom, Achnanthes minutissima, was very common. Unicellular blue-green algae were very common. The highest concentration of blue-green algae, which were mainly unicellular, occurred at 0.5 and 1.04 mg/l of nickel (Table 18).

The phycocyanin extracts indicate that the highest growth of blue-green algae occurred at 0.05 and 0.5 mg/l. At 1.04 mg/l the amount of extracted phycocyanin was not very different (Pl. 5, Fig. 7). When one examines the uptake of accumulation of nickel within the cells, we see that there is a very rapid accumulation to over 10,000 ug/gm at 0.05 mg/l and that this concentration continued to increase with increased concentrations of nickel in the water. It is very evident that this accumulation was detrimental to the uptake of ^{14}C as there was a decrease in ^{14}C per gram of chlorophyll $_a$ from the control to 0.05 mg/l of nickel and it remained about the same at the other concentrations. This decrease was definite but not extreme, indicating that the blue-green algae and green algae were not as effective in the uptake of ^{14}C at these nickel concentrations as were the diatoms in the control. There was more protoplasmic or volatile material in the various nickel concentrations than in the control, pointing to the fact that there was probably more protoplasm present, but per gram of chlorophyll $_a$ it did not take up as much ^{14}C (Pl. 5, Fig. 8; Pl. 7, Fig. 1).

The February-March experiments repeated two of the concentrations used in the November-December experiments--that is, 0.47 mg/l and 1.0 mg/l. The results are quite similar in that in the control the diatoms remained dominant and the diversity was good throughout the experiment. Ulothrix zonata became abundant in the control and blue-green algae remained rare throughout the experiment. In the 0.47 mg/l concentration the diatoms became rare and the diversity was very poor. Achnanthes minutissima was common. The green alga Stigeoclonium lubricum was very frequent and unicellular blue-green algae became common. Similar conditions were found at 1.0 mg/l of nickel (Table 19).

The accumulation experiments showed that at concentrations of 0.47 mg/l of nickel in the water, the nickel accumulated within the biomass was 36,000 ug/gm. This was higher than the amount accumulated during the November-December experiment; likewise, at 1.0 mg/l of nickel in the water, the accumulation of nickel was much higher in the February-March experiments (Pl. 7, Fig. 2).

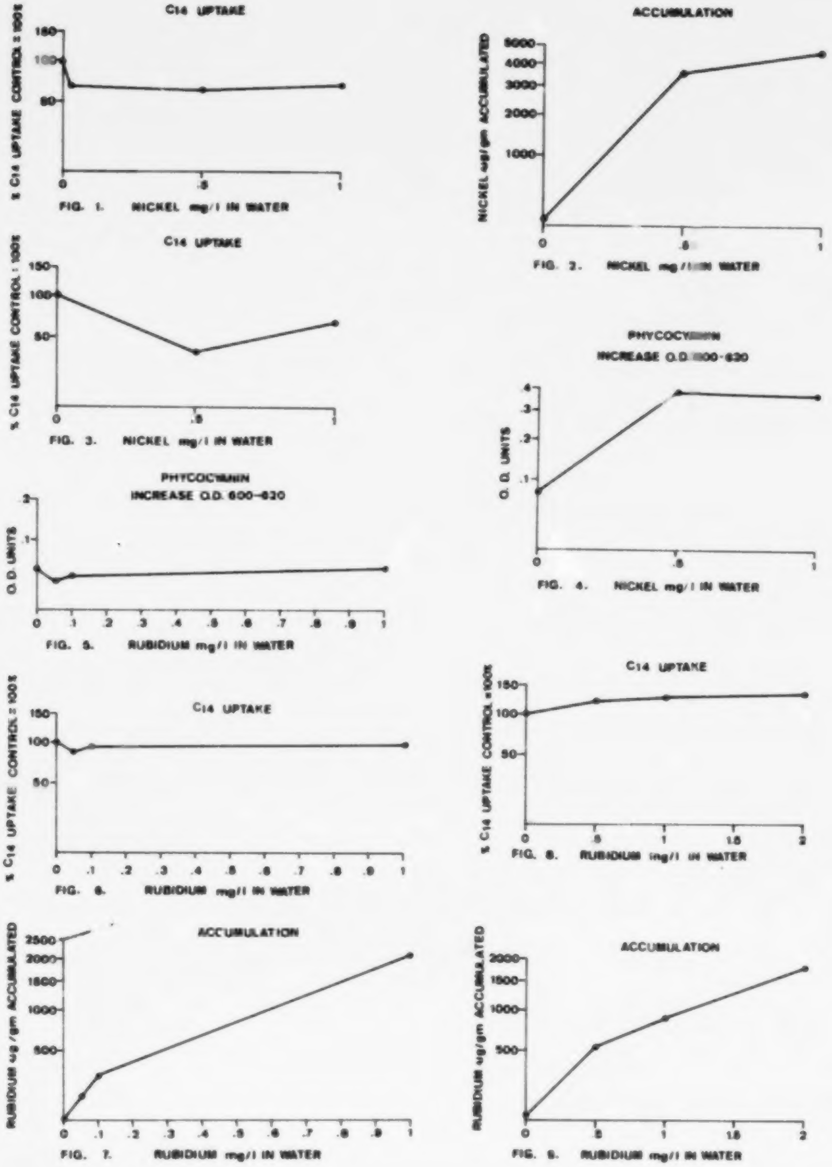

Plate 7. Fig. 1 - Nickel, ^{14}C uptake - % of control (Nov.-Dec.); Fig. 2 - Nickel, accumulation µg/gm (Feb.-Mar.); Fig. 3 - Nickel, ^{14}C uptake - % of control (Feb.-Mar.); Fig. 4 - Nickel, phycocyanin in O.D. units (Feb.-Mar.); Fig. 5 - Rubidium, phycocyanin in O.D. units (June-July); Fig. 6 - Rubidium, ^{14}C uptake - % of control (June - July); Fig. 7 - Rubidium, accumulation µg/gm (June-July); Fig. 8 - Rubidium, ^{14}C uptake - % of control (July-Aug.); Fig. 9 - Rubidium, accumulation µg/gm (July-Aug.).

When one examines the ^{14}C uptake results we see, as in the previous experiments, a decrease in carbon uptake as compared with the control. The decrease at 0.5 mg/l is much more severe than in the November-December experiment. This is probably due to the much greater increase in nickel at this concentration during these experiments than occurred in the November-December experiments (Pl. 7, Fig. 3).

The phycocyanin extractions indicate the increase in blue-green algae at 0.5 mg/l and 1.0 mg/l concentration of nickel in the water. It is interesting to note that at 0.5 and 1.0 mg/l the amounts of phycocyanin were very similar, whereas we find a slight decrease in the November-December experiments. This difference, however, was probably not significant. A much higher increase in phycocyanin occurred in these experiments than in the November-December tests. Since these earlier phycocyanin determinations were not equated as to weight, the greater amount of phycocyanin may be due to a general increase in biomass rather than a proportionally greater growth of blue-green algae. The biomass determinations indicate that the growth was double or more than double in these experiments. All of these experiments show a decided increase in phycocyanin in the nickel-containing tests when compared with the control (Pl. 7, Fig. 4).

The July-August experiments were carried out in order to confirm earlier results. The concentrations tested ranged from 5.9-43.3 ug/l. This was a series run to obtain photographs of the blue-green algae. Data for accumulation of nickel and ^{14}C uptake were not obtained.

The results of these experiments are given in Tables 20, 141-145, and correspond with those of earlier experiments--that is, the diatoms were severely affected by the increase in concentrations of nickel and blue-green algae became very common, increasing in commonness with increases in concentration. These observational notes are also substantiated by the photographs (Plate 8).

The extraction results do not indicate the increase in blue-green algae when compared with the control. The difference in observations and pigment extractions are probably due to Schizothrix calcicola, a very small filamentous blue-green. It can be very abundant but produce very little phycocyanin as compared with the many fewer filaments of the larger species of blue-green algae such as Microcoleus vaginatus. The extraction results indicate that at 36.5 ug/l there was a very decided increase in blue-green algae; at 5.9 ug/l there was some increase but not as pronounced as at 36.5 ug/l. At 6.4 ug/l the extraction indicates that blue-green algae were not as common as in the control; however, this is probably due to the frequent occurrence of Schizothrix calcicola. Observations showed this species was very common at this concentration.

The chlorophyll analyses indicate a decrease in chlorophyll $_c$ as one might expect in the various nickel concentrations. The highest concentrations of diatoms were in the control. The highest amount of chlorophyll $_a$ and lowest amount of chlorophyll $_c$ was at the average concentration of 5.9 ug/l where the green algae Oedogonium and Spirogyra sp. were more common than in the other experiments and blue-green algae were common, but diatom growth was very low.

Figure 1. Control for the nickel experiments, showing dominance of diatoms.

Figure 2. Nickel, 5.9 μg/l. Blue-green algae, Microcoleus vaginatus, dominant.

Figure 3. Nickel, 36.5 μg/l. Blue-green algae, Microcoleus vaginatus, Schizothrix calcicola, and Achnanthes lanceolata.

PLATE 8

The results of these experiments indicate that nickel is deleterious to the growth of diatoms even at very low concentrations and that greens and blue-greens seem to be more tolerant. The blue-greens seem to be much more tolerant of higher concentrations than the greens. It is interesting to note that at the lower concentrations of nickel *Stigeoclonium lubricum* tended to increase in several of the experiments. The accumulation of nickel seems to affect the ^{14}C uptake and, as with other heavy metals, when it reaches a given threshold it can have a very serious affect on ^{14}C uptake. However, some uptake was observed at concentrations of 0.5 mg/l and 1 mg/l in the water although it was significantly lower than the uptake in the control.

RUBIDIUM

Two series of rubidium experiments were carried out: June 30-July 18, 1972, and July 28-August 17, 1972. The average day length in June-July was 14 hours and 50 minutes, being 47 minutes longer than in the July-August experiments.

The chemical background data were quite similar in these two series of experiments. There was considerable variation in manganese concentrations during the course of most of the tests. However, the magnitude of variation and concentrations were similar in all the tests. In the July-August series in test #7 the calcium concentration was at times higher than usual, but not different enough to produce any definite effect (Tables 146-157). The average temperature in both series of experiments was approximately 18°C.

In the June-July experiments diversity and the growth of diatoms were about the same in the control and in the various test concentrations, ranging from 0.054 mg/l to 1.03 mg/l. There did seem to be a slight tendency for the diversity to be less at 1.104 mg/l and 1.03 mg/l. One or more species of green algae were common in most of the tests through the latter half of the experiments. The exception was 0.1 mg/l. There seemed to be no tendency for increased blue-green algae (Table 21). These observational data are supported by the analyses for phycocyanin that show no significant increase with increases in concentrations of rubidium (Pl. 7, Fig. 5).

^{14}C experiments indicate that about the same amount of ^{14}C was taken up in all tests as compared to the control. Thus the various concentrations of rubidium did not seem to affect ^{14}C uptake of the algae nor were they significantly different from that of the control (Pl. 7, Fig. 6).

Rubidium was accumulated by the algae during the course of the experiment. As with other metals, the greatest increase in uptake is at the lower concentrations. There was continued uptake in all concentrations but the concentration per gram of biomass at 1.0 mg/l had not increased in the same proportion to the water concentration as at the lower concentrations. At 1.0 mg/l, 2,160 ug/gm of rubidium were accumulated (Pl. 7, Fig. 7).

The results of the July-August rubidium experiments were very similar to those carried out in June-July (Tables 151-157). As seen from Table 22 diatoms dominated all communities at all times during the experiments.

Likewise, the diversity was good at all times. The green and blue-green algae varied in their commonness. Greens were typically common to fairly rare depending on the species. The blue-green algae were rare to frequent but never were common. Phycocyanin pigment analyses were not carried out. However, there was no observational data that indicated this increase.

As seen by Pl. 7, Fig. 8, the ^{14}C uptake was quite similar in all experiments as one might expect. It seemed to be slightly higher at higher concentrations when compared with the control.

The rubidium accumulation (ug/gm) increased with increased concentration, the greatest rate of increase being between the control and 0.5 mg/l. The slopes of the line compared quite favorably with those in the first series of experiments. The accumulation at 1.0 mg/l was less than half the amount in the first experiment (865 ug/gm compared to 2,160 ug/gm). At 2 mg/l the accumulation was similar but a little less than at 1.0 mg/l in the first series of experiments (Pl. 7, Fig. 9).

From these experiments it would appear that rubidium has no significant effect on the species composition of algal communities in the ranges tested.

SECTION VII

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SECTION VIII

APPENDICES

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APPENDIX A

OBSERVATIONAL NOTES - TABLES

Table 1. **VANADIUM JULY 22 - AUGUST 12, 1971**

Test #	Amount V (µg/1)	Observational Notes 8-7-71*
1	20.0	Diatoms growth - less diversity - good Bluegreens - frequent
5	20.7	As #1
2	8.8	Diatoms diversity - good *Melosira varians* - dominant Bluegreens - frequent
6	9.9	Diatoms diversity - good *M. varians* - dominant Bluegreens - frequent
3	3.4	Diatoms diversity - good *M. varians* - dominant Bluegreens - frequent
7	3.6	Diatoms diversity - good *M. varians* - dominant Bluegreens - frequent +
4	control <1.0	Diatoms diversity - good *M. varians* - dominant Bluegreens - frequent
8	control <1.0	Diatoms diversity - good *M. varians* - dominant Bluegreens - frequent

* No notes made at beginning of experiment. These records were made near the end of the experiment.

Table 2. VANADIUM SEPTEMBER 11-OCTOBER 11, 1971

Test #	Amount V (µg/l)	Observational Notes 9-12-71	 9-26-71	 10-9-71
1	~0	Diatoms - dominant diversity - good Greens - frequent	Diatoms - dominant diversity - good *Melosira varians* - common Greens - frequent Bluegreens - rare	Diatoms - biomass less than control diversity - poorer growth - poor Greens - rare to frequent Bluegreens - common
5	39.7	As #1	Diatoms - dominant diversity - good *M. varians* - common Greens - fairly rare Bluegreens - 15% fields examined	As #1
2	18.4	As #1	Diatoms - dominant diversity - good *M. varians* - common Greens - poorly developed Bluegreens - 10% fields examined, a few filaments	Diatoms - biomass less than control Greens *Stigeoclonium* - rare to frequent Bluegreens - frequent +
6	20.1	As #1	As in #2 except Bluegreens - rare	As #2
3	8.7	As #1	Diatoms - dominant diversity - good *M. varians* - common Greens - rare Bluegreens - 50% fields examined, a few filaments	Diatoms diversity - poor *M. varians* - common Greens - a few protonema of *Stigeoclonium* Bluegreens - common

Table 2 (continued). VANADIUM SEPTEMBER 11 - OCTOBER 11, 1971
Observational Notes

Test #	Amount V (µg/l)	9-12-71	9-26-71	10-9-71
7	9.1	As #1	Diatoms - dominant *M. varians* - common Greens - rare Bluegreens - 10% fields examined, a few filaments	As in #3 except Bluegreens - frequent
4	control	As #1	Diatoms - dominant *M. varians* - common Greens - rare Bluegreens - frequent	Diatoms diversity - good Greens - rare Bluegreens - frequent to common
8	control	As #1	As in #4 except Bluegreens - much less frequent	As #4

Table 3 . VANADIUM NOVEMBER 5 - DECEMBER 12, 1971

Test #	Amount V (mg/l)	Observational Notes 12-3-71
4	control	Diatoms growth - good Bluegreens - frequent
5	4.07	Diatoms growth - poor Bluegreens - thick growth
6	2.02	Diatoms growth - heavy Bluegreens - common
7	0.21	Diatoms growth - good diversity - good Bluegreens - frequent +

Table 4. VANADIUM FEBRUARY 1 - MARCH 11, 1972
Observational Notes

Test #	Amount V (mg/l)	1-29-72	2-8-72	3-8-72
1	4.8	Diatoms diversity- excellent Greens - rare Bluegreens - rare	Diatoms poor condition Greens - present	Diatoms poor condition Greens Ulothrix ? - common Bluegreens - very common
8	4.2	Diatoms diversity - good Greens - frequent Bluegreens - rare	As #1 except some Bluegreens	As #1
4	2	Diatoms diversity - good Greens - common Ulothrix Bluegreens - rare	Diatoms diversity - good Greens Ulothrix - common Stigeoclonium - frequent	Diatoms diversity - good Greens - common Ulothrix Stigeoclonium Bluegreens - rare
6	2	Diatoms diversity - good Greens - frequent Ulothrix Bluegreens - rare	As #4	Diatoms diversity - good Greens Stigeoclonium - very common Bluegreens - very frequent
3	control	Diatoms diversity - good Greens - frequent Ulothrix Stigeoclonium Bluegreens - frequent	Diatoms diversity - good Greens Ulothrix - common Stigeoclonium - frequent	Diatoms diversity - good Greens - present Bluegreens - rare +
5	control	Diatoms diversity - good Greens - common Ulothrix - some Stigeoclonium Bluegreens - fair number	As #3	

Table 5. CHROMIUM MARCH 27 - APRIL 27, 1972

Test #	Amount Cr (μg/l)	4-7 - 4-11-72	4-22-72	4-26 - 4-27-72
		Observational Notes		
8	control	Diatoms - dominant diversity - good Greens *Spirogyra* - common *Ulothrix* - frequent Bluegreens - rare +	Diatoms - dominant diversity - good Bluegreens - frequent	Diatoms - dominant diversity - good Bluegreens - frequent
4	control	Diatoms - dominant diversity - good Greens *Ulothrix* - frequent Bluegreens - rare	Diatoms - dominant diversity - good Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare Bluegreens - frequent
7	49	Diatoms - dominant diversity - good Greens *Ulothrix* - common	Diatoms - dominant diversity - good Bluegreens - frequent	Diatoms - dominant diversity - good Bluegreens - rare
3	50	Diatoms - dominant diversity - fairly good Greens *Stigeoclonium* - rare + Bluegreens - in patches	Diatoms - dominant diversity - good Bluegreens - frequent	Diatoms - dominant diversity - good Bluegreens - frequent
6	97	Diatoms - dominant diversity - fair Greens *Stigeoclonium* - frequent Bluegreens - common	Diatoms - dominant diversity - fair Greens *Stigeoclonium* - frequent *Ankistrodesmus* - abundant Bluegreens - frequent	Diatoms - dominant diversity - fair Greens *Stigeoclonium* - common *Selenastrum* - rare Bluegreens - frequent +

Table 5 (continued). CHROMIUM MARCH 27 - APRIL 27, 1972

Test #	Amount Cr (μg/l)	Observational Notes 4-7 - 4-11-72	4-22-72	4-26 - 4-27-72
2	95	Diatoms - dominant diversity - poor Greens *Stigeoclonium* - present Bluegreens - rare	Diatoms - dominant diversity - poor Bluegreens - frequent	Diatoms - dominant diversity - fair Greens *Stigeoclonium* - common Bluegreens - frequent +
1	397	Diatoms - mostly dead Greens *Stigeoclonium* - abundant Bluegreens - abundant	Diatoms - rare Bluegreens - abundant	Diatoms - rare Greens - rare except *Selanastrum bibraeanum* - common
5	396	Diatoms - mostly dead Greens *Stigeoclonium* - abundant Bluegreens - abundant	Diatoms - rare Bluegreens - abundant	Diatoms - rare Greens - rare Bluegreens - abundant

Table 6 . CHROMIUM MAY 11 - MAY 26, 1972
Observational Notes

Test #	Amount Cr ($\mu g/l$)	5-10-72	5-21-72	5-26-72
4	control	Diatoms - dominant diversity - good Cursory examination	Diatoms - dominant diversity - good Greens Spirogyra - rare Oedogonium - rare Ulothrix - frequent Bluegreens - rare	Diatoms - dominant Greens Ulothrix Stigeoclonium
8	control	Diatoms - dominant diversity - good Cursory examination	Diatoms - dominant diversity - good Greens Ulothrix - frequent Bluegreens - rare	As #4
7	49	Diatoms - dominant diversity - good Cursory examination	Diatoms - dominant diversity - good Greens Ulothrix - frequent Oedogonium - frequent Stigeoclonium - rare Bluegreens - rare +	Diatoms - dominant Greens Ulothrix
3	49	Diatoms - dominant diversity - good Cursory examination	As #7	As #7
2	100	Diatoms - dominant diversity - good Cursory examination	Diatoms - dominant Greens Stigeoclonium - frequent Bluegreens - rare	Diatoms - dominant

Table 6 (continued). **CHROMIUM MAY 11 - MAY 26, 1972**
Observational Notes

Test #	Amount Cr (µg/l)	5-10-72	5-21-72	5-26-72
6	99	Diatoms - dominant diversity - good Cursory examination	Diatoms - dominant good condition diversity - fair Greens Stigeoclonium - common Bluegreens - rare	Diatoms - dominant
1	407	Diatoms - dominant diversity - good Cursory examination	Diatoms - poor condition Greens Stigeoclonium - common Bluegreens - abundant	Diatoms - poor condition Greens Stigeoclonium Unicellular - green Bluegreens - abundant
5	403	Diatoms - dominant diversity - good Cursory examination	As #1	As #1

Table 7. CHROMIUM JUNE 30-JULY 21, 1972
Observational Notes

Test #	Amount Cr (mg/l)	6-27-72	7-15-72	7-21-72
8	control	Diatoms - dominant diversity - good Greens _Stigeoclonium_ - rare _Spirogyra_ - rare Bluegreens - rare	Diatoms - dominant diversity - good Greens _Stigeoclonium_ - frequent + _Spirogyra_ - common Bluegreens - frequent	Diatoms - dominant diversity - good Bluegreens Unicellular algae - frequent
6	0.398	Diatoms - dominant diversity - good Greens _Stigeoclonium_ - rare _Spirogyra_ - rare _Ulothrix_ - rare Bluegreens - rare	Diatoms - poor condition Bluegreens - very common	Diatoms - mostly dead Bluegreens - abundant Unicellular algae - abundant _Schizothrix_ - common _Oscillatoria_ - common
7	3.38	Diatoms - dominant diversity - good Greens _Stigeoclonium_ - rare _Spirogyra_ - rare Bluegreens - rare	Diatoms - poor condition Bluegreens - very common	As # 6

Table 8. CHROMIUM JULY 28 - AUGUST 17, 1972

Observational Notes

Test #	Amount Cr (mg/l)	7-30-72	8-13-72	8-17-72
4	control	Diatoms - dominant diversity - good Greens *Spirogyra* - frequent *Ulothrix* - frequent Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Spirogyra* - frequent + Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Spirogyra* - rare + Bluegreens - rare
8	0.4	As #4	Diatoms - poor condition diversity - poor Bluegreens - very common	Diatoms - mostly dead Bluegreens - very common

Table 9. SELENITE SEPTEMBER 20 - OCTOBER 20, 1972
Observational Notes

Test #	Amount Se (mg/1 SeO3)	9-24-72	10-3-72	10-20-72
1	40.8	Diatoms - excellent Greens - rare Bluegreens - rare	Diatoms - heavy growth Greens - frequent *Stigeoclonium* *Oedogonium*	Diatoms - good growth diversity - poor No Greens No Bluegreens
2	20.9	Diatoms - excellent Greens - rare	Diatoms - heavy growth Greens - frequent *Stigeoclonium* *Oedogonium*	Diatoms - heavy growth diversity - less Greens - rare
3	10.6	Diatoms - excellent Greens - rare	Diatoms - very heavy growth Greens - frequent *Oedogonium* *Cladophora* *Stigeoclonium*	Diatoms - heavy growth Greens - frequent *Stigeoclonium* *Oedogonium* Bluegreens - rare
4	5.4	Diatoms - excellent Greens - rare	Diatoms - good Greens - frequent Bluegreens - frequent	Diatoms - good Greens - frequent + Bluegreens - rare
5	2.6	Diatoms - excellent Greens - rare Bluegreens - rare	Diatoms - good Greens - frequent + *Stigeoclonium* Bluegreens - frequent	Diatoms - good Greens - frequent *Oedogonium* *Spirogyra* Bluegreens - frequent
6	1.04	Diatoms - excellent Greens - rare Bluegreens - rare	Diatoms - excellent Greens - rare Bluegreens - frequent	Diatoms - excellent Greens - frequent *Stigeoclonium* Bluegreens - frequent +

Table 9 (continued). SELENITE SEPTEMBER 20 - OCTOBER 20, 1972

Test #	Amount Se (mg/1 SeO3)	Observational Notes		
		9-24-72	10-3-72	10-20-72
7	0.1	Diatoms - excellent Greens - rare Bluegreens - not seen	Diatoms - excellent Greens - rare Bluegreens - frequent	Diatoms - excellent Greens - frequent *Stigeoclonium* *Spirogyra* Bluegreens - rare
8	control	Diatoms - excellent Greens - rare Bluegreens - rare	Diatoms - excellent Greens - rare Bluegreens - rare	Diatoms - excellent Greens - frequent *Stigeoclonium* *Oedogonium* *Spirogyra* Bluegreens - rare

Table 10. SELENITE NOVEMBER 9 - DECEMBER 4, 1972
Observational Notes

Test #	Amount Se (mg/1)	11-9-72	11-21-72	12-2-72
1	40.9	Diatoms diversity - good Greens - frequent *Stigeoclonium* *Oedogonium* Bluegreens - rare	Diatoms diversity - fair Greens - rare *Stigeoclonium* *Oedogonium* *Ulothrix*	Diatoms diversity - greatly reduced Greens - rare
5	40.3	Diatoms diversity - good Greens - frequent *Stigeoclonium* Bluegreens - rare	As #1	As #1
2	10.4	Diatoms diversity - good Greens - frequent *Stigeoclonium* Bluegreens - rare	Diatoms diversity - good Greens - rare *Stigeoclonium* *Ulothrix* *Oedogonium*	Diatoms - heavy growth diversity - reduced Greens - frequent *Stigeoclonium* *Ulothrix* *Oedogonium*
6	10.3	Diatoms diversity - good Greens - frequent *Stigeoclonium* *Oedogonium* Bluegreens - rare	As #2	As #2 except Greens - rare
3	1.07	Diatoms diversity - good Greens - frequent *Stigeoclonium* *Spirogyra* *Oedogonium* Bluegreens - rare	Diatoms diversity - good Greens - common *Stigeoclonium* - common *Ulothrix* - rare *Oedogonium* - rare	Diatoms - heavy growth diversity - good Greens - frequent *Stigeoclonium* *Ulothrix* *Oedogonium* Bluegreens - rare *Schizothrix*

Table 10(continued). SELENITE NOVEMBER 9 - DECEMBER 4, 1972

Test #	Amount Se (mg/l)	Observational Notes 11-9-72	11-21-72	12-2-72
7	1.04	Diatoms diversity - good Greens - frequent *Stigeoclonium* Bluegreens - rare	As #3	As #3
4	control <0.1	Diatoms diversity - good Greens - frequent *Stigeoclonium* Bluegreens - rare	Diatoms diversity - good Greens - rare *Stigeoclonium* *Oedogonium*	Diatoms diversity - good Greens - rare *Stigeoclonium* *Oedogonium* *Ulothrix* Bluegreens - rare *Schizothrix calcicola* *Oscillatoria*
8	control <0.1	Diatoms diversity - good Greens - frequent *Stigeoclonium* *Oedogonium* Bluegreens - rare	As #4	Diatoms diversity - good Greens - rare *Stigeoclonium* *Oedogonium* *Ulothrix* Bluegreens - rare *Oscillatoria*

Table 11. SELENIUM APRIL 3 - MAY 11, 1973
Observational Notes

Test #	Amount Se (mg/1)	4-3-73	4-8-73	5-7-73
1	41.5 SeO_4	Diatoms - dominant Greens *Stigeoclonium* - frequent Bluegreens - frequent	No living algae	No algae growth
2	10.6 SeO_4	Diatoms - common A little Bluegreen A little *Stigeoclonium*	No Diatoms living A few Bluegreens	No Diatoms living *Schizothrix* - very common
3	1.2 SeO_4	Diatoms - common *Stigeoclonium* - none Bluegreens - very little	Diatoms - very few A little *Stigeoclonium* Lots of Bluegreens	Diatoms - poor Lots of *Stigeoclonium* Bluegreens - common
5	40.5 SeO_3	Diatoms - dominant *Schizothrix* - rare *Oscillatoria* - frequent *Stigeoclonium* - rare	Diatoms - dominant growth - excellent *Schizothrix* - frequent	Diatoms - fair, more than Greens Greens *Stigeoclonium* - fair amount *Schizothrix* - fair-low (biomass much less than 6)
6	10.4 SeO_3	Diatoms - dominant *Oscillatoria* - frequent *Stigeoclonium* - rare to frequent	Diatoms - dominant diversity - less Bluegreens - frequent	Diatoms - poor Greens *Stigeoclonium* - very common *Draparnaldia* - frequent Bluegreens *Schizothrix* - frequent - common
7	1.1 SeO_3	Diatoms - dominant *Oscillatoria* - frequent *Stigeoclonium* - non seen	Diatoms - dominant Bluegreens - common	Diatoms - diversity restricted *Achnanthes lanceolata* - common Greens - common *Stigeoclonium* *Ankistrodesmus* Bluegreens - common

Table 11(continued). SELENIUM APRIL 3 - MAY 11, 1973
Observational Notes

Test #	Amount Se (mg/l)	4-3-73	4-8-73	5-7-73
8	control	Diatoms - dominant Stigeoclonium - rare + Bluegreens - rare +	Diatoms - dominant More Stigeoclonium	Diatoms - dominant Schizothrix calcicola - freqeunt Ulothrix - common

Table12. SELENIUM JUNE 15 - JULY 3, 1973
Observational Notes

Test #	Amount Se (mg/1)	6-9-73	6-21-73	7-1-73
1	40.4 SeO_4	Diatoms - dominant Greens Stigeoclonium - frequent A few Bluegreens	Diatoms - dead or poor condition No Bluegreens or Greens seen	No Diatoms Nothing alive (some Bluegreens)
2	10.3 SeO_4	Diatoms - dominant Stigeoclonium - frequent Ulothrix - frequent	Diatoms - poor condition Greens - poor condition	Diatoms - poor Greens - rare Bluegreens - common Schizothrix
3	1.1 SeO_4	Diatoms - dominant A little Green	Diatoms - a few species good condition diversity - down Greens - common Bluegreens Schizothrix	Diatoms - few Green - common Bluegreens - common
5	40.9 SeO_3	Diatoms - dominant Greens - a few Bluegreens - a few	Diatoms - poor condition	Diatoms - growth heavy Greens - a few
6	10.6 SeO_3	Diatoms - dominant Stigeoclonium protonema - frequent Dluegreens - rare	Diatoms - good condition Greens - frequent + Stigeoclonium protonema	Diatoms - good diversity - not as much as 7 Greens - Cosmarium - frequent Stigeoclonium - rare Bluegreens - frequent -
7	1.1 SeO_3	Diatoms - dominant Greens - frequent Stigeoclonium Closterium	Diatoms - growth excellent	Diatoms - excellent Greens Stigeoclonium - frequent Bluegreens - a few

Table 12(continued). SELENIUM JUNE 15 - JULY 3, 1973

Test #	Amount Se (mg/1)	Observational Notes		
		6-9-73	6-21-73	7-1-73
8	control	Diatoms - dominant Greens - frequent *Stigeoclonium* *Closterium*	Diatoms - growth excellent Greens - a few Bluegreens - few	Diatoms - diversity good

Table 13 BORON MAY 20 - JUNE 13, 1970
Observational Notes

Test #	Amount B (mg/l)	5-27-70	6-5-70	6-13-70
1	control 0.03	Diatoms - dominant diversity - good Greens - fairly common Bluegreens - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare Bluegreens common in spots (frequent overall)	Diatoms - dominant Greens Unicellular - rare Bluegreens - rare
2	0.15	Diatoms - dominant diversity - good Greens *Closterium* - rare Bluegreens - frequent	Diatoms - dominant Greens *Stigeoclonium* - rare Unicellular - common Bluegreens - common	Diatoms - dominant Greens *Cosmarium* - frequent *Stigeoclonium* - rare Bluegreens - very common
3	0.52	Diatoms - dominant Greens - quite common Bluegreens - quite common	Diatoms - dominant Greens *Stigeoclonium* - rare Unicellular - frequent Bluegreens - common	As #2
4	1.07	Diatoms - dominant Greens - rare	Diatoms - dominant Greens *Stigeoclonium* - very common Bluegreens - common	Diatoms - poor condition Greens *Cosmarium* - abundant *Stigeoclonium* - rare Bluegreens - abundant

Table 14. BORON JUNE 26 - AUGUST 6, 1970
Observational Notes

Test #	Amount B (mg/1)	7-3-70	7-20-70	7-26-70
1	control 0.029	Diatoms - dominant diversity - good Greens *Stigeoclonium protonema* - frequent Unicellular - frequent	Diatoms - dominant diversity - good Bluegreens - frequent	Diatoms - dominant diversity - good Bluegreens - rare
2	0.118	Diatoms - dominant Greens Unicellular - frequent Bluegreens Filamentous - frequent + Unicellular - frequent +	Diatoms - diverse Bluegreens - very common	Diatoms - diverse Bluegreens - common
3	0.52	Diatoms - growth fair *Melosira* - frequent Greens *Stigeoclonium* - frequent + Unicellular - rare Bluegreens - frequent +	As #2	As #2, Bluegreens more common
4	1.05	Diatoms - growth common Greens *Stigeoclonium* - common + Unicellular - rare Bluegreens Unicellular - common Filamentous - frequent	Diatoms - present Greens *Stigeoclonium* - very common Bluegreens - very common	Diatoms - present Greens *Stigeoclonium* - very common Bluegreens - very common

Table 15. BORON SEPTEMBER 24-NOVEMBER 4, 1970
Observational Notes

Test #	Amount B (mg/l)	9-20-70	10-12-70	11-2-70
1	control 0.032	Diatoms - dominant diversity - good Greens Stigeoclonium - frequent Bluegreens - frequent	Diatoms - dominant diversity- good Greens Spirogyra - common Scenedesmus - very common Bluegreens - frequent +	Diatoms - dominant diversity - fair Greens Spirogyra - common Bluegreens - frequent
2	0.125	Diatoms - dominant diversity - good	Diatoms - dominant diversity - less than control Greens Scenedesmus - abundant Unicellular - very common Spirogyra - common Bluegreens Unicellular - very common Filamentous - common	As # 1 Except Bluegreens - fairly common
3	0.488	Diatoms - dominant diversity - good	Diatoms diversity - poor Greens Scenedesmus - common + Spirogyra - common Bluegreens - abundant	Diatoms diversity - poor Greens Spirogyra - common Bluegreens - very common Filamentous - common Unicellular - common
4	1.04	Diatoms - dominant diversity - good	Diatoms - common diversity - poor Greens Spirogyra - frequent Bluegreens - abundant	Diatoms - common diversity - poor Greens Spirogyra - very common Bluegreens - abundant

Table 16. NICKEL MARCH 29 - APRIL 29, 1971
Observational Notes

Test #	Amount Ni (µg /l)	4-1-71	4-13-71	4-25-71
1	8.6	Diatoms - dominant diversity - good Greens Ulothrix - common Stigeoclonium - present	Diatoms diversity - poor Greens Ulothrix - very common Stigeoclonium - frequent Ankistrodesmus Bluegreens - frequent +	Diatoms - very few Greens Ulothrix - abundant Scenedesmus - common Bluegreens - abundant
8	7.6	Diatoms - dominant diversity - fair Greens Ulothrix - common	Diatoms diversity -poor Greens Ulothrix - common Stigeoclonium - common Bluegreens - frequent	Diatoms diversity - fair Greens Ulothrix - common Bluegreens - abundant
5	4.78		Diatoms diversity - poor Greens Ulothrix - very common Stigeoclonium - very common Bluegreens - common	Diatoms diversity - poor Greens Ulothrix - abundant Bluegreens - abundant
7	4.54	Diatoms - dominant diversity - good Greens Ulothrix - common	Diatoms diversity - poor Ulothrix - very common Bluegreens - common	Diatoms diversity - poor Bluegreens - abundant
2	2.0	Diatoms - dominant diversity - good Greens Ulothrix - common	Diatoms - dominant Greens Ulothrix - common Stigeoclonium - frequent Bluegreens - rare	Diatoms diversity - fair Greens Ulothrix - frequent Spirogyra - frequent Bluegreens - frequent

Table 16 (continued). NICKEL MARCH 29 - APRIL 29, 1971

Test #	Amount Ni ($\mu g/l$)	Observational Notes 4-1-71	 4-13-71	 4-25-71
6	2.21	Diatoms - dominant diversity - good Greens Stigeoclonium - common Ulothrix - common	Diatoms diversity - fair Greens Ulothrix - common Stigeoclonium - frequent Bluegreens - very common	Diatoms diversity - poor Greens Stigeoclonium - common Bluegreens - abundant
3	control	Diatoms - dominant diversity - good Greens Ulothrix - common	Diatoms diversity - good Greens Ulothrix - frequent Stigeoclonium - common Bluegreens - frequent	Diatoms diversity - good Greens Ulothrix - frequent Stigeoclonium - frequent Spirogyra - frequent Bluegreens - frequent
4	control	Diatoms - dominant diversity - fair Greens Ulothrix - frequent +	As #3	Diatoms diversity - good Greens Cosmarium - rare Scenedesmus - rare Bluegreens - frequent

Table 17. NICKEL MAY 22 - JULY 13, 1971
Observational Notes

Test #	Amount Ni (µg/1)	5-15-71	6-1-71	6-24 - 7-2-71
3	control	Diatoms - dominant diversity - good Greens *Ulothrix* - rare + Colonial greens - rare + *Stigeoclonium* - frequent Bluegreens - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent Unicellular - rare Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent ? Bluegreens - rare
4	control	As #3	Diatoms - dominant diversity - good Greens *Stigeoclonium* - common	As #3
2	2.2	Diatoms -dominant diversity - good Greens *Ulothrix* - rare *Spirogyra* - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - common Unicellular - rare	Diatoms - dominant Greens *Stigeoclonium* - frequent Bluegreens - very common
6	2.3	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent *Ulothrix* - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - common Bluegreens - rare +	As #2 Bluegreens not quite so common
5	4.9	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent *Ulothrix* - rare *Spirogyra* - rare	As #6 Bluegreens - a little less	Diatoms - frequent condition - fair Greens *Stigeoclonium* - very common *Ankistrodesmus* - frequent Bluegreens - common
7	5.1	As #5 except no *Spirogyra*	Diatoms - dominant Greens *Stigeoclonium* - common Bluegreens - frequent	As #5 except Bluegreens very common

Table 17 (continued). NICKEL MAY 22 - JULY 31, 1971

Test #	Amount Ni (µg/1)	Observational Notes 5-15-71	6-1-71	6-24 - 7-2-71
8	8.1	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent *Closterium* - frequent *Ulothrix* - rare Unicellular - rare Bluegreens - rare	Diatoms - dominant Greens *Stigeoclonium* - common *Unicellular* - rare Bluegreens - rare	Diatoms - frequent Greens *Stigeoclonium* - very common *Ankistrodesmus* - frequent Bluegreens - common
1	9.1	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent *Ulothrix* - rare	As #8	As #8

Table 18 NICKEL NOVEMBER 5 - DECEMBER 12, 1971
Observational Notes

Test #	Amount Ni (mg/1)	11-16-71	12-3-71
1	1.04	Diatoms only *Achnanthes minutissima* reproducing - most plasmolized Greens - fairly common	Diatoms *Achnanthes minutissima* - very common Greens *Stigeoclonium protonema* - frequent Bluegreens - unicellular - very common
2	0.5	Diatoms - better than 1 fair condition Greens *Stigeoclonium protonema* - common	As #1
3	0.05	Diatoms diversity - good Greens *Stigeoclonium* - frequent Bluegreens - rare	Diatoms diversity - good Greens *Stigeoclonium* - rare *Spirogyra* - rare Bluegreens - frequent
4	control	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare Bluegreens - frequent

Table 19. NICKEL FEBRUARY 1 - MARCH 11, 1972
Observational Notes

Test #	Amount Ni (mg/1)	1-29-72	2-8-72	3-5/3-8-72
3	control	Diatoms - dominant diversity - good Greens *Stigeoclonium* *protonema* - frequent Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare + *Ulothrix* - frequent + Bluegreens - rare	Diatoms - dominant diversity - good Greens *Ulothrix* - abundant Bluegreens - rare
5	control	Diatoms - dominant diversity - good Greens *Stigeoclonium* - frequent *Ulothrix* - common Bluegreens - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare + *Ulothrix* - frequent + Bluegreens - rare	Diatoms - dominant diversity - good Greens *Ulothrix* - abundant Bluegreens - rare
2	0.47	Diatoms - dominant diversity - good Greens *Stigeoclonium* - common *Ulothrix* - frequent + Bluegreens - rare	Diatoms - poor condition diversity - poor Greens *Stigeoclonium* - common *Ulothrix* - rare Bluegreens - rare	Diatoms - only a few species diversity - poor Greens *Stigeoclonium* - frequent + Bluegreens Unicellular - common
7	1.0	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare *Ulothrix* - frequent + Bluegreens - rare	Diatoms - poor condition diversity - poor Greens *Stigeoclonium* - common Bluegreens - rare	Diatoms - poor condition diversity - poor Greens *Stigeoclonium* - frequent Bluegreens Unicellular - common

Table 20. NICKEL JULY 20 - AUGUST 20, 1973

Test #	Amount Ni (µg/1)	7-20-73	8-10-73	8-19-73
		Observational Notes		
8	Control	Diatoms - dominant diversity - good Bluegreens - rare	Diatoms - dominant some dead diversity - good Greens Oedogonium - rare Spirogyra -rare Closterium - rare	Diatoms - dominant Greens Oedogonium - rare Spirogyra - rare Bluegreens - frequent
3	6.4	Diatoms - dominant diversity - good Greens Stigeoclonium - rare− Unicellular green rare+ Bluegreens - rare	Diatoms - growth low diversity - low Greens Oedogonium - rare Spirogyra - rare Bluegreens - very common	Diatoms - growth low good condition diversity low Greens Oedogonium - rare Bluegreens - common
7	5.9	Diatoms - dominant diversity - good Greens Stigeoclonium - rare Oedogonium - rare Spirogyra - rare poor condition	As in # 3	Diatoms - good condition growth - low diversity - low Greens Oedogonium - frequent Spirogyra - frequent Bluegreens - common
6	36.5	Diatoms - dominant diversity - good Greens Stigeoclonium - rare Bluegreens - rare	Diatoms - growth low diversity - low Greens - Spirogyra - rare Bluegreens - very common	Diatoms - growth low health of few species - good diversity - poor Greens Oedogonium - rare Bluegreens - very common

Table 20(continued). NICKEL JULY 20 - AUGUST 20, 1973

Test #	Amount Ni (µg/l)	Observational Notes		
		7-20-73	8-10-73	8-19-73
2	43.3	Diatoms - dominant diversity - good Greens Stigeoclonium - frequent Oedogonium - rare Unicellular green - rare Bluegreens - rare	Diatoms - poor condition Bluegreens - common	Diatoms - poor condition Greens Spirogyra - rare Oedogonium - rare Bluegreens - common

Table 21. RUBIDIUM JUNE 30 - JULY 18, 1972
Observational Notes

Test #	Amount Rb (mg/l)	6-27-72	7-15-72
5	1.03	Diatoms - dominant Greens *Stigeoclonium* - frequent *Spirogyra* - rare *Ulothrix* - rare Bluegreens - rare	Diatoms - dominant diversity - not as good as control Greens *Spirogyra* - common, healthy *Oedogonium* - frequent *Stigeoclonium* - frequent + Bluegreens - rare
1	0.10	Diatoms - dominant Greens *Stigeoclonium* - frequent *Spirogyra* - rare Bluegreens - rare	Diatoms - dominant diversity - less than control Greens *Stigeoclonium* - rare + *Spirogyra* - poor condition Bluegreens - a few filaments
2	0.05	As #1	Diatoms diversity - good Greens *Oedogonium* - rare *Mougeotia* - rare *Stigeoclonium* - common Bluegreens - not seen
3	0.05	As # 1 plus some *Ulothrix*	Diatoms diversity - good Greens *Spirogyra* - common *Stigeoclonium* - frequent + Bluegreens - rare
4	control	As #5	Diatoms - dominant diversity - good Greens *Spirogyra* - common Bluegreens - not seen

Table 22 RUBIDIUM JULY 28 - AUGUST 17, 1972
Observational Notes

Test #	Amount Rb (mg/l)	7-30-72	8-13-72	8-17-72
3	0.48	Diatoms - dominant diversity - good Greens Spirogyra - rare Ulothrix - rare + Unicellular - rare + Bluegreens - rare	Diatoms - dominant diversity - good Greens Spirogyra - frequent Oedogonium - rare Ulothrix - rare	Diatoms - dominant diversity - good Greens Spirogyra - rare + Bluegreens - rare
7	0.48	Diatoms - dominant diversity - good Greens Ulothrix - frequent Spirogyra - frequent Stigeoclonium - rare Bluegreens - rare	As #3	As #3 except: Spirogyra - frequent Bluegreens - frequent
2	1.0	Diatoms - dominant diversity - good Greens Spirogyra - rare Ulothrix - rare Unicellular - rare	Diatoms - dominant diversity - good Greens Spirogyra - common Ulothrix - rare Bluegreens - rare	As #3 except Spirogyra common
6	1.0	Diatoms - dominant diversity - good Greens Spirogyra - fairly common Ulothrix - rare Stigeoclonium - rare Unicellular - rare Bluegreens - rare	Diatoms - dominant diversity - good Greens Spirogyra - common Ulothrix - rare Pediastrum - rare Oedogonium - rare Bluegreens - rare	As #3 except: Spirogyra - common Oedogonium - rare

Table 22 (continued). RUBIDIUM JULY 28 - AUGUST 17, 1972

Test #	Amount Rb (mg/l)	Observational Notes 7-30-72	8-13-72	8-17-72
1	2.0	Diatoms - dominant diversity - good Greens *Spirogyra* - rare *Ulothrix* - rare *Stigeoclonium* - rare Unicellular - rare Bluegreens - rare	Diatoms - dominant diversity - good Greens *Spirogyra* - frequent + Bluegreens - rare	As #6 except no Bluegreens seen
5	1.99	Diatoms - dominant diversity - good Greens *Stigeoclonium* - fairly common *Ulothrix* - frequent *Spirogyra* - frequent Unicellular - rare Bluegreens - rare	Diatoms - dominant diversity - good Greens *Stigeoclonium* - rare *Ulothrix* - rare *Spirogyra* - frequent + Bluegreens - rare	As #2
4	control	Diatoms - dominant diversity - good Greens *Spirogyra* - frequent *Ulothrix* - frequent Bluegreens - frequent	Diatoms - dominant diversity - good Greens *Spirogyra* - frequent + Bluegreens - frequent	As #3

APPENDIX B

CHARTS OF CHEMICAL AND PHYSICAL DATA - TABLES

Table 23. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 5 20.7 µg/l V

Chemical or physical analysis		X̄	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.89°	1.476°	0.0714°	17.22° -2*	13.33° -2*	20
pH		7.538	0.543	0.024	9.0 -1	6.3 -1	19
NO_3-N	mg/l	2.14	0.6288	1.681	3.25 -1	1.48 -1	14
PO_4-P	mg/l	0.115	0.0429	0.0107	0.186 -1	0.039 -1	16
NH_3-N	mg/l	0.150	0.0848	0.0346	0.278 -1	0.066 -1	6
SO_4	mg/l	25.8	--	--	31.2 -1	20.3 -1	2
SiO_2	mg/l	15.8	2.501	0.6684	20.3 -1	12.0 -1	14
Alk-P	mg/l	00.0	--	--	00.0 -	00.0 -	9
Alk-MO	mg/l	54.2	8.333	2.777	76.0 -1	48.0 -1	9
Cl	mg/l	14.0	--	--	16.0 -1	12.0 -1	4
Ca Hard.	mg/l	69.0	--	--	74.0 -1	64.0 -1	2
Tot. Hard.	mg/l	90.0	--	--	94.0 -1	86.0 -1	2
V	µg/l	20.7	7.274	1.878	32.0 -2	6.5 -1	15
Zn		—	—	—	—	—	—
Cu		—	—	—	—	—	—
Mn	mg/l	0.089	0.1005	0.0268	0.36 -1	0.024 -1	14
Fe	mg/l	0.15	0.0722	0.0195	0.30 -1	0.05 -2	14
Na	mg/l	5.9	--	--	6.0 -1	5.7 -1	2
K	mg/l	2.2	--	--	2.2 -1	2.2 -1	2
Daylength		14'11"			14'33"	13'47"	

* For pH and temperature -# = hours of occurrence
For chemicals -# = times of occurrence

Table 24. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 1 20.3 μg/l V

Chemical or physical analysis		$\bar{X}$	SD $\pm$	SE $\pm$	Maximum	Minimum	N
Temp.	°C	14.50°	2.452°	0.1292°	20.0° -2	8.33° -1	19
pH	mg/l	7.607	0.527	0.024	8.7 -2	6.0 -4	19
NO_3-N	mg/l	1.89	0.839	0.2245	3.25 -1	1.08 -2	14
PO_4-P	mg/l	0.123	0.0469	0.0117	0.228 -1	0.049 -1	16
NH_3-N	mg/l	0.107	0.0591	0.0241	0.20 -1	0.036 -1	6
SO_4	mg/l	25.3	--	--	31.0 -1	19.6 -1	2
SiO_2	mg/l	14.6	2.755	0.7263	18.6 -1	10.9 -1	14
Alk-P	mg/l	00.0	--	--	--	--	--
Alk-MO	mg/l	53.1	1.764	0.5879	56.0 -1	50.0 -1	9
Cl	mg/l	12.5	--	--	14.0 -1	12.0 -3	4
Ca Hard.	mg/l	56.0	--	--	58.0 -1	54.0 -1	2
Tot. Hard.	mg/l	96.0	--	--	100.0 -1	92.0 -1	2
V	μg/l	20.3	9.098	2.431	45.0 -1	8.1 -1	14
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/l	0.089	0.0942	0.0252	0.381 -1	0.001 -1	14
Fe	mg/l	0.16	0.0762	0.0204	0.32 -1	0.06 -2	14
Na	mg/l	6.0	--	--	6.0 -1	6.0 -1	1
K	mg/l	2.2	--	--	2.2 -1	2.2 -1	1
Daylength		14'11"			14'33"	13'47"	

Table 25. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 6 9.9 µg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.17°	4.906°	0.2368°	18.89° -1	13.89° -1	20
pH		7.679	0.561	0.026	9.0 -1	6.2 -1	19
NO_3-N	mg/l	2.02	0.6737	0.1801	3.14 -1	1.50 -2	14
PO_4-P	mg/l	0.113	0.0412	0.0103	0.179 -1	0.042 -1	16
NH_3-N	mg/l	0.087	0.0353	0.0144	0.134 -1	0.041 -1	6
SO_4	mg/l	25.8	--	--	31.3 -1	20.2 -1	2
SiO_2	mg/l	16.2	2.200	0.5880	19.4 -1	12.6 -1	14
Alk-P	mg/l	00.0	--	--	00.0	00.0	9
Alk-MO	mg/l	51.6	3.127	1.042	54.0 -3	44.0 -1	9
Cl	mg/l	12.0	--	--	12.0 -	12.0 -	4
Ca Hard.	mg/l	56.0	--	--	58.0 -1	54.0 -1	2
Tot. Hard.	mg/l	99.0	--	--	100.0 -1	98.0 -1	2
V	µg/l	9.93	4.366	1.211	21.0 -1	2.8 -1	13
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/l	0.085	0.0944	0.0252	0.177 -1	0.015 -1	14
Fe	mg/l	0.15	0.0621	0.0166	0.28 -1	0.07 -1	14
Na	mg/l	5.8	--	--	6.3 -1	5.3 -1	2
K	mg/l	2.1	--	--	2.2 -1	2.0 -1	2
Daylength		14'11"			14'33"	13'47"	

Table 26. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 2 8.8 µg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.94°	4.120°	0.2167°	20.56° -2	8.33° -1	19
pH		7.736	0.527	0.024	8.9 -1	6.2 -5	19
NO_3-N	mg/l	2.04	0.5882	0.1572	3.25 -1	1.45 -1	14
PO_4-P	mg/l	0.105	0.0447	0.0111	0.186 -1	0.029 -1	16
NH_3-N	mg/l	0.108	0.0640	0.0261	0.20 -1	0.026 -1	6
SO_4	mg/l	25.1	--	--	31.4 -1	18.8	2
SiO_2	mg/l	14.6	2.757	0.7369	18.4 -1	9.8 -1	14
Alk-P	mg/l	--	--	--	00.0	00.0	9
Alk-MO	mg/l	52.7	2.645	0.8819	56.0 -2	48.0 -1	9
Cl	mg/l	14.5	--	--	16.0 -2	12.0 -1	4
Ca Hard.	mg/l	56.0	--	--	58.0 -1	54.0 -1	2
Tot. Hard.	mg/l	98.0	--	--	98.0 -1	98.0 -1	2
V	µg/l	8.8	3.299	0.8817	13.0 -1	2.3 -1	14
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/l	0.089	0.0819	0.0219	0.159 -1	0.015 -1	14
Fe	mg/l	0.17	0.0685	0.0183	0.31 -1	0.08 -1	14
Na	mg/l	6.1	--	--	6.1 -1	6.1 -1	1
K	mg/l	2.1	--	--	2.1 -1	2.1 -1	1
Daylength		14'11"			14'33"	13'47"	

Table 27. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 3 3.4 µg/l V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.17°	4.510°	0.2379°	22.22° -1	8.33° -1	19
pH		7.826	0.542	0.024	9.0 -3	6.3 -1	19
NO_3-N	mg/l	1.76	0.7481	0.1999	3.01 -1	1.02 -1	14
PO_4-P	mg/l	0.108	0.0424	0.0106	0.190 -1	0.049 -2	16
NH_3-N	mg/l	0.084	0.0500	0.0204	0.134 -1	<0.02 -1	6
SO_4	mg/l	24.6	--	--	29.5 -1	19.7 -1	2
SiO_2	mg/l	14.0	3.166	0.8462	19.5 -1	9.8 -1	14
Alk-P	mg/l	00.0	--	--	00.0	00.0	8
Alk-MO	mg/l	53.3	2.815	0.9955	58.0 -1	50.0 -2	8
Cl	mg/l	13.5	--	--	16.0 -1	10.0 -1	4
Ca Hard.	mg/l	53.3	--	--	54.0 -1	52.0 -1	3
Tot. Hard.	mg/l	99.0	--	--	112.0 -1	86.0 -1	2
V	µg/l	3.44	2.538	0.704	11.0 -1	1.0 -1	13
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/l	0.079	0.0907	0.0242	0.182 -1	0.014 -1	14
Fe	mg/l	0.13	0.0567	0.0152	0.26 -1	0.07 -1	14
Na	mg/l	6.3	--	--	6.3 -1	6.3 -1	1
K	mg/l	2.2	--	--	2.2 -1	2.2 -1	1
Daylength		14'11"			14'33"	13'47"	

Table 28. SUMMARY CHART – VANADIUM 7-22-71/8-12-71

Test 7 3.6 µg/1 V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.28°	3.264°	0.1584°	18.89° -1	13.89° -9	20
pH		7.748	0.603	0.028	9.0 -2	6.2 -1	19
NO_3-N	mg/1	1.96	0.8811	0.2355	3.26 -1	0.54 -1	14
PO_4-P	mg/1	0.097	0.0433	0.0108	0.186 -1	0.029 -1	16
NH_3-N	mg/1	0.078	0.0453	0.0185	0.128 -1	<0.02 -1	6
SO_4	mg/1	26.8	--	--	31.3 -1	22.2 -1	2
SiO_2	mg/1	15.2	3.259	0.8713	20.7 -1	11.8 -2	14
Alk-P	mg/1	00.0	--	--	00.0 -	00.0 -	8
Alk-MO	mg/1	52.8	1.832	0.6478	56.0 -1	50.0 -1	8
Cl	mg/1	12.5	--	--	14.0 -1	12.0 -3	4
Ca Hard.	mg/1	54.0	--	--	54.0 -1	54.0 -1	2
Tot. Hard.	mg/1	88.0	--	--	90.0 -1	86.0 -1	2
V	µg/1	3.6	1.694	0.4698	7.0 -1	1.0 -2	13
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/1	0.069	0.0866	0.0231	0.136 -1	0.013 -1	14
Fe	mg/1	0.12	0.0573	0.0153	0.24 -1	0.05 -1	14
Na	mg/1	6.6	--	--	6.8 -1	6.3 -1	2
K	mg/1	2.4	--	--	2.6 -1	2.2 -1	2
Daylength		14·11"			14'33"	13'47"	

Table 29. SUMMARY CHART - VANADIUM 7-22-71/8-12-71
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.17°	4.001°	0.7109°	16.11° -1	8.33° -1	19
pH		8.074	0.552	0.026	9.1 -3	6.5 -1	19
NO_3-N	mg/l	1.80	0.7138	0.1907	2.99 -1	1.12 -1	14
PO_4-P	mg/l	0.106	0.0424	0.0106	18.6 -2	0.039 -1	16
NH_3-N	mg/l	0.084	0.0387	0.0157	0.136 -1	0.032 -1	6
SO_4	mg/l	25.0	--	--	29.6 -1	20.4 -1	2
SiO_2	mg/l	15.6	2.591	0.6924	18.8 -2	12.0 -1	14
Alk-P	mg/l	00.0	--	--	00.0	00.0	8
Alk-MO	mg/l	51.3	2.121	0.7500	54.0 -2	48.0 -1	8
Cl	mg/l	12.7	--	--	14.0 -1	12.0 -2	3
Ca Hard.	mg/l	56.0	--	--	58.0 -1	54.0 -1	2
Tot. Hard.	mg/l	89.0	--	--	90.0 -1	88.0 -2	2
V	mg/l	<1.0	--	--	<1.0 -	<1.0 -	12
Zn		—	—	—	—	—	—
Cu		—	—	—	—	—	—
Mn	mg/l	0.076	0.0753	0.0201	0.177 -1	0.010 -1	14
Fe	mg/l	0.14	0.0783	0.0209	0.32 -1	0.06 -2	14
Na	mg/l	6.1	--	--	6.1 -1	6.1 -1	1
K	mg/l	2.1	--	--	2.1 -1	2.1 -1	1
Daylength		14'11"			14'33"	13'47"	

Table 30. SUMMARY CHART - VANADIUM 7-22-71/8-12-71

Test 8 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.50°	2.222°	0.107°	20.0° -1	13.89° -9	20
pH		7.798	0.597	0.028	9.0 -1	6.3 -1	19
NO_3-N	mg/l	1.76	0.7145	0.1909	2.98 -1	0.95 -1	14
PO_4-P	mg/l	0.097	0.0498	0.0124	0.209 -1	0.023 -1	16
NH_3-N	mg/l	0.089	0.0467	0.0190	0.147 -1	0.020 -1	6
SO_4	mg/l	24.9	--	--	30.1 -1	19.7 -1	2
SiO_2	mg/l	14.6	2.718	0.7264	19.0 -1	11.2 -1	14
Alk-P	mg/l	00.0	--	--	00.0	00.0	8
Alk-MO	mg/l	54.3	4.334	1.532	62.0 -1	48.0 -1	8
Cl	mg/l	12.7	--	--	14.0 -1	12.0 -2	3
Ca Hard.	mg/l	47.0	--	--	52.0 -1	42.0 -1	2
Tot. Hard.	mg/l	87.0	--	--	90.0 -1	84.0 -1	2
V	µg/l	<1.0	--	--	<1.0 -	<1.0 -	12
Zn		--	--	--	--	--	--
Cu		--	--	--	--	--	--
Mn	mg/l	0.089	0.1105	0.0306	0.42 -1	0.012 -1	13
Fe	mg/l	0.13	0.0681	0.0189	0.26 -1	0.05 -1	13
Na	mg/l	5.9	--	--	6.1 -1	5.8 -1	2
K	mg/l	2.3	--	--	2.4 -1	2.2 -1	2
Daylength		14'11"			14'33"	13'47"	

Table 31. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 1 40.7 µg/1 V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	oC	14.22°	3.940°	0.1552°	25.00°	11.11°	595
pH		7.468	0.434	0.014	9.0 -1	6.6 -8	30
NO_3-N	mg/1	2.82	0.2885	0.0643	3.33 -1	2.46 -1	20
PO_4-P	mg/1	0.159	0.0804	0.0185	0.323-1	0.057-1	19
NH_3-N	mg/1	0.072	0.0343	0.0139	0.113-1	0.024-1	6
SO_4	mg/1	24.6	6.605	3.302	30.8 -1	15.3 -1	4
SiO_2	mg/1	18.4	3.500	0.7829	24.6 -1	10.4 -1	20
Alk-P	mg/1	—	—	—	—	—	—
Alk-MO	mg/1	48.7	3.000	1.000	52.0 -3	44.0 -1	9
Cl	mg/1	14.7	4.163	2.404	18.0 -1	10.0 -1	3
Ca Hard.	mg/1	52.0	4.320	2.160	58.0 -1	48.0 -1	4
Tot. Hard.	mg/1	96.0	6.928	4.000	104.0 -1	92.0 -2	3
V	µg/1	40.7	6.024	1.256	51.0 -1	30.0 -1	23
Zn	mg/1	0.0116	0.0038	0.0017	0.0155 -1	0.0056 -1	5
Cu	mg/1	0.0227	0.0047	0.0019	0.029-1	0.015-1	6
Mn	mg/1	0.180	0.1146	0.0256	0.472-1	0.035-1	20
Fe	mg/1	0.24	0.0904	0.0202	0.41 -1	0.10 -1	20
Na	mg/1	6.1	0.7852	0.3926	7.0 -1	5.1 -1	4
K	mg/1	2.75	0.2646	0.1323	3.1 -1	2.45 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 32. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 5 39.7 μg/1 V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.28°	2.80°	0.11°	21.11°	9.44°	595
pH		7.360	0.363	0.010	8.5 -6	6.2 -1	30
NO_3-N	mg/1	2.95	0.2777	0.0621	3.57 -1	2.49 -1	20
PO_4-P	mg/1	0.147	0.0759	0.0174	0.310-1	0.068-1	19
NH_3-N	mg/1	0.060	0.0182	0.0074	0.084-1	0.028-1	6
SO_4	mg/1	25.5	6.536	3.268	31.2 -1	16.1 -1	4
SiO_2	mg/1	19.9	2.647	0.5918	23.6 -1	14.8 -1	20
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	48.2	1.202	0.4006	50.0 -2	46.0 -1	9
Cl	mg/1	13.3	2.309	1.333	16.0 -1	12.0 -2	3
Ca Hard.	mg/1	56.5	4.726	2.363	60.0 -2	50.0 -1	4
Tot. Hard.	mg/1	102.0	10.00	5.774	112.0 -1	92.0 -1	3
V	μg/1	39.7	5.663	1.207	51.0 -1	28.0 -1	22
Zn	mg/1	0.007	0.002	0.001	0.010-1	0.003-1	5
Cu	mg/1	0.017	0.005	0.002	0.023-1	0.009-1	6
Mn	mg/1	0.165	0.1126	0.0252	0.467-1	0.028-1	20
Fe	mg/1	0.20	0.0875	0.0195	0.41 -1	0.09 -1	20
Na	mg/1	6.03	0.7632	0.3816	6.9 -1	5.1 -1	4
K	mg/1	2.78	0.4015	0.2008	3.3 -1	2.45 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 33. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 6 20.1 µg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.39°	3.24°	0.13°	21.67°	10.56°	596
pH		7.410	0.373	0.014	8.6 -2	6.6 -1	30
NO_3-N	mg/l	2.94	0.3799	0.0849	3.57 -1	2.26 -1	20
PO_4-P	mg/l	0.151	0.0756	0.0173	0.306-1	0.067-1	19
NH_3-N	mg/l	0.058	0.0221	0.0090	0.084-1	0.020-1	6
SO_4	mg/l	27.1	7.111	3.556	32.0 -1	16.6 -1	4
SiO_2	mg/l	18.7	2.883	0.6447	22.4 -1	14.2 -1	20
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	48.2	2.333	0.7777	52.0 -1	44.0 -1	9
Cl	mg/l	12.0	2.000	1.154	14.0 -1	10.0 -1	3
Ca Hard.	mg/l	58.5	5.972	2.986	64.0 -1	50.0 -1	4
Tot. Hard.	mg/l	104.7	4.619	2.667	110.0 -1	102.0 -2	3
V	µg/l	20.1	3.752	0.7999	25.7 -1	12.5 -1	22
Zn	mg/l	0.007	0.002	0.001	0.010-1	0.004-1	5
Cu	mg/l	0.012	0.004	0.002	0.017-1	0.007-1	6
Mn	mg/l	0.127	0.0769	0.0172	0.327-1	0.046-1	20
Fe	mg/l	0.22	0.1061	0.0237	0.39 -1	0.09 -2	20
Na	mg/l	5.95	0.6245	0.3122	6.7 -1	5.2 -1	4
K	mg/l	2.82	0.4337	0.2188	3.4 -1	2.46 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 34. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 2 18.4 μg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.94°	4.848°	0.1905°	26.11°	11.11°	596
pH		7.390	0.553	0.020	9.0 -2	6.3 -4	30
NO_3-N	mg/l	2.89	0.3425	0.0766	3.66 -1	2.39 -1	20
PO_4-P	mg/l	0.148	0.0846	0.0194	0.326-1	0.049-1	19
NH_3-N	mg/l	0.059	0.0188	0.007	0.084-1	0.028-1	6
SO_4	mg/l	26.0	7.645	3.823	31.6 -1	14.8 -1	4
SiO_2	mg/l	18.1	2.663	0.5956	21.8 -1	14.3 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	51.1	8.253	2.751	72.0 -1	44.0 -1	9
Cl	mg/l	13.3	1.155	0.6666	14.0 -2	12.0 -1	3
Ca Hard.	mg/l	60.0	11.78	5.888	76.0 -1	48.0 -1	4
Tot. Hard.	mg/l	98.3	5.507	3.179	102.0	92.0	3
V	μg/l	18.4	2.572	0.5484	23.0 -2	13.0 -1	22
Zn	mg/l	0.007	0.002	0.001	0.009-1	0.004-1	5
Cu	mg/l	0.010	0.003	0.001	0.014-1	0.005-1	6
Mn	mg/l	0.124	0.0864	0.0193	0.375-1	0.038-1	20
Fe	mg/l	0.22	0.1097	0.0245	0.41 -1	0.09 -1	20
Na	mg/l	5.9	0.5795	0.2898	6.5 -1	5.1 -1	4
K	mg/l	2.7	0.4272	0.2136	3.3 -1	2.4 -2	4
Daylength		11'59"			12'36"	11'21"	

Table 35. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 7 9.1 µg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.00°	3.62°	0.15°	22.78°	10.56°	595
pH		7.511	0.348	0.010	8.8 -4	6.8 -7	30
NO_3-N	mg/l	2.76	0.3011	0.0673	3.30 -1	2.27 -1	20
PO_4-P	mg/l	0.145	0.0816	0.0187	0.303-1	0.055-2	19
NH_3-N	mg/l	0.083	0.0432	0.0177	0.166-1	0.043-1	6
SO_4	mg/l	26.4	7.809	3.904	33.6 -1	15.6 -1	4
SiO_2	mg/l	16.4	2.547	0.5695	21.9 -1	12.5 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	48.4	6.227	2.076	60.0 -1	40.0 -1	9
Cl	mg/l	12.7	2.309	1.33	14.0 -2	10.0 -1	3
Ca Hard.	mg/l	56.0	6.325	3.162	62.0 -1	48.0 -1	4
Tot. Hard.	mg/l	92.7	10.06	5.812	102.0 -1	82.0 -1	3
V	µg/l	9.1	1.637	0.3490	12.0 -1	5.5 -1	22
Zn	mg/l	0.004	0.001	0.0005	0.005-1	0.002-1	5
Cu	mg/l	0.007	0.002	0.001	0.011-1	0.003-1	6
Mn	mg/l	0.115	0.1105	0.0247	0.405-1	0.020-1	20
Fe	mg/l	0.19	0.1059	0.0237	0.42 -1	0.05 -1	20
Na	mg/l	5.93	0.7089	0.3544	6.9 -1	5.2 -1	4
K	mg/l	2.88	0.3847	0.1924	3.4 -1	2.5 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 36. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 3 8.7 µg/1 V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.28°	5.022°	0.1977	26.11°	11.11°	595
pH		7.345	0.542	0.020	9.0 -4	6.5 -7	30
NO_3-N	mg/l	2.77	0.3327	0.0744	3.39 -1	2.25 -1	20
PO_4-P	mg/l	0.145	0.0867	0.0199	0.316-2	0.049-1	19
NH_3-N	mg/l	0.063	0.0145	0.0059	0.087-1	0.043-1	6
SO_4	mg/l	27.9	8.127	4.064	35.6 -1	16.4 -1	4
SiO_2	mg/l	17.3	2.847	0.6366	22.1 -1	12.8 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	46.9	2.848	0.9493	50.0 -2	42.0 -1	9
Cl	mg/l	12.0	2.000	1.155	14.0 -1	10.0 -1	3
Ca Hard.	mg/l	55.5	6.608	3.304	62.0 -1	48.0 -1	4
Tot. Hard.	mg/l	95.0	13.75	7.937	110.0 -1	83.0 -1	3
V	µg/l	8.7	1.803	0.3843	13.0 -1	5.5 -1	22
Zn	mg/l	0.006	0.002	0.0008	0.007-1	0.003-1	5
Cu	mg/l	0.008	0.002	0.0009	0.011-1	0.004-1	6
Mn	mg/l	0.106	0.0672	0.0150	0.267-1	0.027-1	20
Fe	mg/l	0.18	0.0972	0.0217	0.35 -1	0.07 -1	20
Na	mg/l	6.1	0.3416	0.1708	6.5 -1	5.7 -1	4
K	mg/l	2.77	0.3515	0.1758	3.2 -1	2.46 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 37. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 4 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.89°	5.579°	0.2190°	26.11°	11.11°	610
pH		7.384	0.511	0.017	9.0 -2	6.6 -5	30
NO_3-N	mg/l	2.75	0.2878	0.064	3.14 -1	2.21 -1	20
PO_4-P	mg/l	0.149	0.0862	0.0198	0.313-1	0.072-1	19
NH_3-N	mg/l	0.059	0.0307	0.0125	0.084-1	<0.02 -1	6
SO_4	mg/l	26.7	7.162	3.581	32.0 -1	16.3 -1	4
SiO_2	mg/l	16.2	2.407	0.5383	19.7 -1	11.8 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	46.9	3.756	1.252	52.0 -1	40.0 -1	9
Cl	mg/l	12.0	0.0000	0.0000	12.0	12.0	3
Ca Hard.	mg/l	54.0	4.899	2.449	58.0 -2	48.0 -1	4
Tot. Hard.	mg/l	94.7	6.429	0.3712	102.0 -1	90.0 -1	3
V	μg/l	—	—	—	<1.0 -18	<0.3 -4	22
Zn	mg/l	0.006	0.002	0.0008	0.007-1	0.003-1	5
Cu	mg/l	0.008	0.002	0.0009	0.011-1	0.004-1	6
Mn	mg/l	0.095	0.0609	0.0136	0.267-1	0.030-1	20
Fe	mg/l	0.19	0.0132	0.0231	0.38 -1	0.06 -1	4
Na	mg/l	5.85	0.5449	0.2723	6.5 -1	5.2 -1	4
K	mg/l	2.67	0.5082	0.2541	3.3 -1	2.1 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 38. SUMMARY CHART - VANADIUM 9-12-71/10-11-71
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.83°	3.90°	0.16°	23.33°	10.56°	510
pH		7.421	0.537	0.020	9.0 -1	6.4 -3	30
NO_3-N	mg/l	2.65	0.3447	0.0771	3.46 -1	2.08 -1	20
PO_4-P	mg/l	0.125	0.0819	0.0818	0.300-1	0.039-1	19
NH_3-N	mg/l	0.066	0.0138	0.0056	0.085-1	0.053-1	6
SO_4	mg/l	27.9	7.993	3.996	34.0 -1	16.5 -1	4
SiO_2	mg/l	15.0	2.478	0.5542	20.0 -1	9.17 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	48.0	1.732	0.5773	50.0 -3	46.0 -3	9
Cl	mg/l	12.7	3.055	1.764	16.0 -1	10.0 -1	3
Ca Hard.	mg/l	56.0	5.657	2.828	60.0 -2	48.0 -1	4
Tot. Hard.	mg/l	100.0	15.09	8.718	116.0 -1	86.0 -1	3
V	µg/l	—	—	—	<1.0 -18	<0.3 -4	22
Zn	mg/l	0.007	0.003	0.001	0.010 -1	0.004-1	5
Cu	mg/l	0.008	0.003	0.001	0.012 -1	0.004-1	6
Mn	mg/l	0.103	0.0730	0.0163	0.307-1	0.021-1	20
Fe	mg/l	0.17	0.0866	0.0194	0.34 -1	0.07 -1	20
Na	mg/l	6.08	0.4787	0.2394	6.7 -1	5.7 -2	4
K	mg/l	2.80	0.4568	0.2284	3.4 -1	2.36 -1	4
Daylength		11'59"			12'36"	11'21"	

Table 39. SUMMARY CHART - VANADIUM 11-5-71/12-12-71
Test 5 4.0 mg/l V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	20.00°	2.0°	0.3°	24.72° -2	15.00° -3	38
pH		7.21	0.42	0.06	9.3 -1	6.1 -1	38
NO_3-N	mg/l	3.05	0.2354	0.0491	3.47 -1	2.41 -1	23
PO_4-P	mg/l	0.138	0.0769	0.0154	0.359 -1	0.033 -2	25
NH_3-N	mg/l	0.087	0.0781	0.0217	0.26 -1	<0.02 -2	13
SO_4	mg/l	72.9	0.3753	11.32	84.0 -1	52.0 -1	11
SiO_2	mg/l	18.5	2.614	0.5449	22.7 -1	15.2 -1	23
Mg	mg/l	7.83	0.1768	0.1250	7.95 -1	7.70 -1	2
Alk-MO	mg/l	13.9	7.109	1.482	32.0 -1	4.0 -1	23
Cl	mg/l	8.3	1.506	0.6146	10.0 -2	6.0 -1	6
Ca Hard.	mg/l	53.6	2.608	1.166	56.0 -2	50.0 -1	5
Tot. Hard.	mg/l	101.0	10.39	5.196	116.0 -1	94.0 -2	4
V	mg/l	4.07	0.3833	0.0639	5.00 -1	3.45 -1	36
Ni	mg/l	--	--	--	<0.03 -	<0.03 -	6
Zn	mg/l	0.033	0.0078	0.0054	0.038 -1	0.027 -1	2
Cu	mg/l	0.019	0.0014	0.0010	0.020 -1	0.018 -1	2
Mn	mg/l	0.29	0.1412	0.0246	0.72 -1	0.045 -1	33
Fe	mg/l	0.15	0.0777	0.0147	0.51 -1	0.06 -1	28
Na	mg/l	8.8	2.704	0.7499	15.8 -1	5.7 -1	13
Ca	mg/l	21.5	0.1414	0.1000	21.6 -1	21.4 -1	2
K	mg/l	2.64	0.1197	0.0379	2.80 -1	2.4 -1	10
Daylength		9'47"			10'21"	9'23"	

Table 40. SUMMARY CHART - VANADIUM 11-5-71/12-12-71
Test 6 2.0 mg/l V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.50°	2.2°	0.3°	24.44° -2	14.44° -3	38
pH		7.46	0.40	0.06	8.9 -3	6.5 -1	38
NO_3-N	mg/l	2.65	0.4785	0.0998	3.17 -1	0.84 -1	23
PO_4-P	mg/l	0.125	0.0413	0.0082	0.179 -1	0.046 -1	25
NH_3-N	mg/l	0.096	0.0783	0.0217	0.24 -2	<0.02 -1	13
SO_4	mg/l	45.4	5.143	1.485	53.6 -1	37.0 -1	12
SiO_2	mg/l	14.9	3.905	0.8143	20.6 -1	7.1 -1	23
Mg	mg/l	7.77	0.0495	0.0350	7.80 -1	7.73 -1	2
Alk-MO	mg/l	28.1	9.021	1.881	50.0 -1	18.0 -2	23
Cl	mg/l	10.7	1.033	0.4216	12.0 -2	10.0 -4	6
Ca Hard.	mg/l	53.6	4.099	1.833	60.0 -1	50.0 -2	5
Tot. Hard.	mg/l	99.5	2.517	1.258	102.0 -1	96.0 -1	4
V	mg/l	2.02	0.1689	0.0285	2.44 -1	1.65 -1	35
Ni	mg/l	--	--	--	<0.03 -	<0.03 -	5
Zn	mg/l	0.015	0.0071	0.0050	0.020 -1	0.010 -1	2
Cu	mg/l	0.006	--	--	0.007 -1	0.005 -1	2
Mn	mg/l	0.26	0.1821	0.0322	0.66 -1	0.038 -1	32
Fe	mg/l	0.18	0.1643	0.0322	0.92 -1	0.07 -2	26
Na	mg/l	6.59	0.7062	0.2233	6.9 -1	5.6 -1	10
Ca	mg/l	21.8	0.4243	0.3000	22.1 -1	21.5 -1	2
K	mg/l	3.57	0.6579	0.2081	4.55 -1	2.6 -1	10
Daylength		9'47"			10'21"	9'23"	

Table 41. SUMMARY CHART - VANADIUM 11-5-71/12-12-71
Test 7 0.21 mg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.72°	2.0°	0.3°	24.72° -4	14.44° -3	38
pH		7.74	0.31	0.04	9.1 -1	6.5 -1	38
NO_3-N	mg/l	2.58	0.4947	0.1032	3.33 -1	1.31 -1	23
PO_4-P	mg/l	0.127	0.0598	0.0119	0.228 -1	0.031 -1	25
NH_3-N	mg/l	0.092	0.0742	0.0206	0.25 -1	<0.02 -1	13
SO_4	mg/l	25.4	25.4	1.026	32.0 -1	19.4 -1	12
SiO_2	mg/l	13.7	13.7	0.9804	20.6 -1	4.0 -1	23
Mg	mg/l	7.72	0.0212	0.0150	7.73 -1	7.70 -1	2
Alk-MO	mg/l	49.3	4.070	0.8487	60.0 -1	42.0 -1	23
Cl	mg/l	10.7	2.422	0.9888	14.0 -1	8.0 -2	6
Ca Hard.	mg/l	52.0	7.071	3.162	58.0 -1	40.0 -1	5
Tot. Hard.	mg/l	106.0	12.11	6.055	124.0 -1	98.0 -1	5
V	mg/l	0.21	0.0323	0.0057	0.31 -1	0.16 -1	32
Ni	mg/l	--	--	--	<0.03 -	<0.03 -	6
Zn	mg/l	0.013	--	--	0.013 -1	0.013 -1	2
Cu	mg/l	0.011	0.0070	0.0004	0.011 -1	0.010 -1	2
Mn	mg/l	0.217	0.1354	0.0236	0.496 -1	0.040 -1	33
Fe	mg/l	0.19	0.1334	0.0257	0.77 -1	0.06 -1	27
Na	mg/l	6.44	0.4904	0.1551	7.1 -1	5.6 -1	10
Ca	mg/l	22.0	0.2828	0.2000	22.2 -1	21.8 -1	2
K	mg/l	4.25	1.062	0.3360	6.3 -1	2.9 -1	10
Daylength		9'47"			10'21"	9'23"	

Table 42. SUMMARY CHART - VANADIUM 11-5-71/12-12-71
Test 4 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.27°	2.1°	0.3°	26.39°	-4	15.00°	-4	38
pH		7.50	0.32	0.04	8.8	-2	6.5	-1	38
NO_3-N	mg/l	2.73	0.4227	0.0860	3.25	-1	1.13	-1	24
PO_4-P	mg/l	0.105	0.0423	0.0084	0.189	-1	0.046	-1	25
NH_3-N	mg/l	0.089	0.0703	0.0195	0.248	-1	0.020	-2	13
SO_4	mg/l	26.7	7.658	2.309	44.4	-1	18.5	-1	11
SiO_2	mg/l	15.5	3.899	0.8129	21.3	-1	7.8	-1	23
Mg	mg/l	7.91	0.0566	0.0400	7.95	-	7.87	-	2
Alk-MO	mg/l	51.9	6.321	1.318	66.0	-1	44.0	-2	23
Cl	mg/l	11.3	1.633	0.6666	14.0	-1	10.0	-2	6
Ca Hard.	mg/l	56.0	4.000	1.788	60.0	-1	50.0	-1	5
Tot. Hard.	mg/l	98.0	5.889	2.944	104.0	-1	90.0	-1	4
V	µg/l	--	--	--	<0.1	-	<0.1	-	32
Ni	mg/l	--	--	--	<0.03	-	<0.03	-	31
Zn	mg/l	0.012	0.0028	0.0020	0.014	-1	0.01	-1	2
Cu	mg/l	0.008	--	--	0.008	-1	0.008	-1	2
Mn	mg/l	0.084	--	--	0.237	-1	0.025	-2	32
Fe	mg/l	0.16	0.1170	0.0225	0.59	-1	0.06	-1	27
Na	mg/l	7.86	2.161	0.6833	12.5	-1	5.4	-1	10
Ca	mg/l	22.5	0.7778	0.5500	23.0	-1	21.9	-1	2
K	mg/l	3.01	0.3229	0.1076	3.6	-1	2.7	-2	9
Daylength		9'47"			10'21"		9'23"		

Table.43. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 1 4.87 mg/l V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.61°	—	—	23.89° -1	13.33° -1	41
pH		7.277	0.268	0.031	8.6 -1	6.4 -1	40
NO_3-N	mg/l	2.81	0.4118	0.0824	3.57 -1	2.09 -1	25
PO_4-P	mg/l	0.098	0.0325	0.0060	0.150 -1	0.040 -1	29
NH_3-N	mg/l	0.044	0.0498	0.0133	0.143 -2	<0.02 -5	14
SO_4	mg/l	46.9	5.192	1.836	51.8 -1	38.8 -1	8
SiO_2	mg/l	12.1	1.956	0.3632	16.0 -1	8.6 -1	29
Alk-P	mg/l	0.00	--	--	--	--	26
Alk-MO	mg/l	22.1	12.46	2.444	58.0 -1	10.0 -3	26
Cl	mg/l	9.2	4.022	1.272	18.0 -1	4.0 -1	10
Ca Hard.	mg/l	46.0	3.899	1.176	52.0 -1	38.0 -1	11
Tot. Hard.	mg/l	87.3	8.345	2.950	102.0 -1	78.0 -2	8
V	mg/l	4.87	0.2476	0.0431	4.87 -1	3.74 -1	33
Ni	mg/l	<0.03	--	--	<0.03 -	<0.03 -	16
Zn	mg/l	0.023	0.0042	0.0014	0.023 -1	0.012 -1	7
Cu	mg/l	0.007	--	--	0.007 -1	<0.005 -3	4
Mn	mg/l	0.468	0.0857	0.0141	0.468 -1	0.013 -1	37
Fe	mg/l	0.49	0.0785	0.0139	0.49 -1	0.06 -2	32
Na	mg/l	30.8	7.804	1.951	30.8 -1	5.3 -2	16
K	mg/l	4.2	0.6015	0.1345	4.2 -1	2.0 -2	20
Daylength		10'55"			11'43"	10'08"	

Table 44. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 8 4.19 mg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	18.67°	--	--	24.44°	-	10.00°	-1	41
pH		7.409	0.272	0.043	9.0	-1	6.7	-1	40
NO_3-N	mg/l	2.66	0.5904	0.1181	3.52	-1	1.78	-1	25
PO_4-P	mg/l	0.097	0.0461	0.0085	1.66	-1	0.026	-1	29
NH_3-N	mg/l	0.061	0.0563	0.0150	0.196	-1	<0.02	-2	14
SO_4	mg/l	46.5	5.080	1.796	53.6	-1	40.8	-1	8
SiO_2	mg/l	10.9	2.624	0.4873	15.8	-1	7.3	-1	29
Alk-P	mg/l	--	--	--	0.0	-	--	-	25
Alk-MO	mg/l	29.1	14.05	2.809	58.0	-2	14.0	-3	25
Cl	mg/l	11.4	2.319	0.7333	15.0	-1	18.0	-1	10
Ca Hard.	mg/l	47.6	3.325	1.002	52.0	-2	42.0	-1	11
Tot. Hard.	mg/l	87.5	6.024	2.129	92.0	-2	74.0	-1	8
V	mg/l	4.19	0.2713	0.0477	4.84	-1	3.50	-1	33
Ni	mg/l	<0.03	--	--	<0.03	-	<0.03	-	18
Zn	mg/l	0.018	0.0058	0.0020	0.025	-1	0.007	-1	7
Cu	mg/l	<0.005	--	--	<0.005	-	<0.005	-	4
Mn	mg/l	0.159	0.0965	0.0158	3.86	-1	0.037	-1	37
Fe	mg/l	0.13	0.0589	0.0104	0.40	-1	0.07	-4	32
Na	mg/l	9.7	5.933	1.483	21.8	-1	5.1	-1	16
K	mg/l	4.1	1.442	0.3224	9.1	-1	1.95	-1	20
Daylength		10'55"			11'43"		10'08"		

Table 45. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 6 2.09 mg/l V

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	18.67°	--	--	23.89°	-3	10.56°	-1	41
pH		7.597	0.390	0.062	9.0	-3	6.8	-14	40
NO_3-N	mg/l	2.55	0.4649	0.0929	3.44	-1	1.94	-1	25
PO_4-P	mg/l	0.104	0.0604	0.0112	0.235	-1	0.030	-1	29
NH_3-N	mg/l	0.052	0.0428	0.0114	0.140	-1	<0.02	-5	14
SO_4	mg/l	30.7	7.473	2.642	36.5	-1	15.8	-1	8
SiO_2	mg/l	8.9	3.272	0.6076	15.9	-1	4.2	-1	29
Alk-P	mg/l	--	--	--	0.0	-	--	-	26
Alk-MO	mg/l	38.2	10.39	2.039	56.0	-1	20.0	-1	26
Cl	mg/l	10.8	1.398	0.4422	12.0	-5	8.0	-1	10
Ca Hard.	mg/l	50.4	3.776	1.138	58.0	-1	44.0	-1	11
Tot. Hard.	mg/l	88.3	9.223	3.261	106.0	-1	74.0	-1	8
V	mg/l	2.09	0.1458	0.0258	2.45	-1	1.75	-1	32
Ni	mg/l	<0.03	--	--	0.03	-	<0.03	-	17
Zn	mg/l	0.017	0.0057	0.0020	0.025	-1	0.077	-1	7
Cu	mg/l	<0.005	--	--	< 0.005	-	<0.005	-	4
Mn	mg/l	0.166	0.1033	0.0165	0.390	-1	0.016	-1	39
Fe	mg/l	0.14	0.0697	0.0123	0.39	-1	0.07	-4	32
Na	mg/l	5.7	0.3124	0.0866	6.1	-1	5.1	-1	13
K	mg/l	4.56	1.921	0.4406	7.7	-1	1.85	-1	19
Daylength		10'55"			11'43"		10'08"		

Table 46. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 4 2.0 mg/l V

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.94°	—	—	24.44° -1	13.33° -1	41
pH		7.497	0.212	0 .031	9.0 -7	6.6 -4	40
NO_3-N	mg/l	2.53	0.5066	0.1013	3.5 -1	1.72 -1	25
PO_4-P	mg/l	0.094	0.0490	0.0091	0.196 -1	0.026 -1	29
NH_3-N	mg/l	0.061	0.0479	0.0128	0.149 -1	<0.02 -1	14
SO_4	mg/l	32.9	3.805	1.345	35.8 -1	23.7 -1	8
SiO_2	mg/l	8.9	3.549	0.6592	16.0 -2	4.2 -1	29
Alk-P	mg/l	00.0	--	--	00.0 -	00.0 -	--
Alk-MO	mg/l	38.9	10.63	2.085	58.0 -2	24.0 -1	26
Cl	mg/l	9.8	1.476	0.4666	12.0 -2	8.0 -3	10
Ca Hard.	mg/l	48.5	1.572	0.4741	50.0 -5	46.0 -2	11
Tot. Hard.	mg/l	85.0	11.21	3.964	104.0 -1	72.0 -1	8
V	mg/l	2.08	0.1369	0.0242	2.39 -1	1.87 -1	32
Ni	mg/l	<0.03	--	--	<0.03 -	<0.03 -	18
Zn	mg/l	0.013	0.0051	0.0017	0.020 -1	0.005 -1	7
Cu	mg/l	<0.005	--	--	<0.005 -	<0.005 -	4
Mn	mg/l	0.132	0.0969	0.0157	0.476 -1	0.023 -1	38
Fe	mg/l	0.13	0.0562	0.0099	0.30 -1	0.06 -1	32
Na	mg/l	5.7	0.3760	0.1043	6.2 -1	5.0 -2	13
K	mg/l	3.6	1.138	0.2612	5.4 -1	1.9 -1	19
Daylength		10'55"			11'43"	10'08"	

Table 47. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 3 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	18.67°	—	—	23.89°		13.33°		41
pH		7.838	0.311	0.044	9.1	-1	6.5	-3	40
NO_3-N	mg/l	2.52	0.4479	0.0896	3.46	-1	1.95	-1	25
PO_4-P	mg/l	0.096	0.0617	0.0114	0.235	-1	0.016	-1	29
NH_3-N	mg/l	0.043	0.0533	0.0142	0.162	-1	<0.02	-6	14
SO_4	mg/l	20.0	2.625	0.9282	24.7	-1	17.1	-1	8
SiO_2	mg/l	10.3	3.018	0.5604	16.1	-1	5.4	-1	29
Alk-P	mg/l	00.0	--	--	00.0		00.0		—
Alk-MO	mg/l	47.3	4.746	0.9308	58.0	-1	38.0	-2	26
Cl	mg/l	10.8	1.932	0.6110	14.0	-1	8.0	-2	10
Ca Hard.	mg/l	48.9	3.506	1.057	56.0	-1	44.0	-2	11
Tot. Hard.	mg/l	86.3	8.031	2.839	98.0	-1	78.0	-2	8
V	mg/l	<0.10	--	--	<0.10	-	<0.10	-	15
Ni	mg/l	<0.03	--	--	<0.03	-	<0.03	-	18
Zn	mg/l	0.011	0.0057	0.0020	<0.017	-1	<0.005	-1	7
Cu	mg/l	<0.005	--	--	<0.005	-	<0.005	-	4
Mn	mg/l	0.126	0.1145	0.0179	0.461	-1	0.016	-1	41
Fe	mg/l	0.14	0.1076	0.0190	0.68	-1	0.05	-1	32
Na	mg/l	5.8	0.3550	0.0935	6.2	-2	5.0	-1	13
K	mg/l	3.5	0.9915	0.2275	4.8	-1	1.85	-1	19
Daylength		10'55"			11'43"		10'08"		

Table 48. SUMMARY CHART - VANADIUM 2-1-72/3-11-72
Test 5 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.67°	--	--	24.44°	10.56°	41
pH		7.700	0.353	0.056	9.0 -8	7.0 -2	40
NO_3-N	mg/l	2.58	0.4502	0.0900	3.44 -1	1.94 -1	25
PO_4-P	mg/l	0.093	0.0566	0.0105	0.241 -1	0.033 -2	29
NH_3-N	mg/l	0.049	0.0486	0.0129	0.159 -1	<0.02 -4	14
SO_4	mg/l	19.9	2.651	0.9373	23.6 -1	16.7 -1	8
SiO_2	mg/l	10.5	2.646	0.4914	16.0 -1	6.4 -1	29
Alk-P	mg/l	00.0	--	--	00.0 -	00.0 -	26
Alk-MO	mg/l	47.1	4.907	0.9622	62.0 -1	34.0 -1	26
Cl	mg/l	11.2	1.687	0.5333	14.0 -1	10.0 -6	10
Ca Hard.	mg/l	48.2	2.442	0.7363	50.0 -6	44.0 -2	11
Tot. Hard.	mg/l	84.0	5.952	2.104	96.0 -1	78.0 -2	8
V	mg/l	<0.10	--	--	<0.10 -	<0.10 -	14
Ni	mg/l	<0.03	--	--	<0.03 -	<0.03 -	17
Zn	mg/l	0.010	0.0057	0.0020	0.015 -2	<0.005 -2	7
Cu	mg/l	<0.005	--	--	<0.005 -	<0.005 -	4
Mn	mg/l	0.135	0.1366	0.0213	0.501 -1	0.029 -1	41
Fe	mg/l	0.15	0.0944	0.0167	0.60 -1	0.05 -1	32
Na	mg/l	5.7	0.3662	0.1016	6.2 -1	4.9 -1	13
K	mg/l	3.62	1.136	0.2605	5.3 -1	1.9 -1	19
Daylength		10'55"			11'43"	10'08"	

Table 49. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 1 397 µg/l Cr

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.17°	3.567°	0.1334°	25.56°	-1	14.44°	-2	712
pH		7.424	0.334	0.000	8.7	-4	6.7	-1	32
NO_3-N	mg/l	2.36	0.5875	0.1253	3.23	-1	1.49	-2	22
PO_4-P	mg/l	0.106	0.0477	0.0097	0.215	-1	0.023	-1	24
NH_3-N	mg/l	0.092	0.0809	0.0233	0.31	-1	<0.02	-1	12
SO_4	mg/l	22.3	3.039	1.241	25.7	-1	18.5	-1	6
SiO_2	mg/l	12.5	1.342	0.2739	15.0	-1	10.6	-2	24
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	46.0	2.451	0.5624	50.0	-2	42.0	-1	19
Cl	mg/l	10.6	1.408	0.4978	12.0	-3	8.0	-1	8
Ca Hard.	mg/l	47.8	3.916	1.305	56.0	-1	42.0	-1	9
Tot. Hard.	mg/l	88.9	5.100	1.700	99.2	-1	80.0	-1	9
Cr	µg/l	397.0	19.7	3.0	450.0	-1	250.0	-1	39
Zn	mg/l	0.009	0.0057	0.0022	0.015	-1	<0.005	-1	6
Cu	mg/l	<0.005	--	—	<0.005	-1	<0.005	-1	3
Mn	mg/l	0.109	0.0852	0.0133	0.440	-1	0.022	-1	41
Fe	mg/l	0.13	0.0559	0.0103	0.24	-1	0.03	-1	29
Na	mg/l	6.3	1.262	0.3644	9.3	-1	4.9	-1	12
K	mg/l	2.6	0.3646	0.1053	3.1	-1	2.0	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 50. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 5 396 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	20.61°	3.493 °	1.315 °	25.00° -2	15.00° - 3	705
pH		7.570	0.317	0.000	8.7 -2	6.8 - 5	32
NO_3-N	mg/l	2.52	0.6023	0.1284	3.79 -1	1.63 - 1	22
PO_4-P	mg/l	0.081	0.310	0.0063	0.175 -1	0.010 - 1	24
NH_3-N	mg/l	0.095	0.0664	0.192	0.250 -1	<0.02 - 1	12
SO_4	mg/l	22.3	3.685	1.504	26.0 -1	17.1 - 1	6
SiO_2	mg/l	12.4	1.309	0.2672	14.5 -1	9.8 - 1	24
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	45.4	2.088	0.4789	50.0 -1	42.0 - 1	19
Cl	mg/l	11.5	1.792	0.6335	14.0 -1	8.0 - 1	8
Ca Hard.	mg/l	48.8	3.583	1.194	54.8 -1	44.2 - 1	9
Tot. Hard.	mg/l	86.1	8.899	2.966	106.0 -1	79.4 - 1	9
Cr	µg/l	396.0	17.6	2.6	430.0 -1	350.0 - 2	39
Zn	mg/l	0.009	0.0046	0.0017	0.013 -1	<0.005 - 1	6
Cu	mg/l	<0.005	—	—	<0.005 -	<0.005 -	3
Mn	mg/l	0.098	0.0615	0.0096	0.230 -1	0.011 - 1	41
Fe	mg/l	0.12	0.0478	0.0088	0.23 -2	0.04 - 2	29
Na	mg/l	5.5	0.3326	0.0960	5.9 -2	4.9 - 1	12
K	mg/l	2.5	0.2609	0.0753	2.9 -1	2.0 - 1	12
Daylength		13'05"			13'44"	12'26"	32

Table 51. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 6 97 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	20.50°	3.503°	0.1319°	25.00°	-2	15.00°	-2	703
pH		7.771	0.362	0.000	8.9	-2	6.5	-2	32
NO_3-N	mg/l	2.14	0.7154	0.1525	3.15	-1	1.01	-1	22
PO_4-P	mg/l	0.076	0.0374	0.0076	0.150	-1	0.009	-1	24
NH_3-N	mg/l	0.092	0.0610	0.0176	0.230	-1	<0.02	-1	12
SO_4	mg/l	23.7	3.285	1.341	26.9	-1	19.0	-1	6
SiO_2	mg/l	10.6	2.324	0.4745	14.6	-2	5.5	-1	24
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	48.4	3.355	0.7679	54.6	-1	44.0	-1	19
Cl	mg/l	14.6	5.369	1.898	26.0	-1	10.0	-1	8
Ca Hard.	mg/l	51.2	4.571	1.524	59.8	-1	45.8	-1	9
Tot. Hard.	mg/l	81.2	4.421	1.474	88.2	-1	76.0	-1	9
Cr	µg/l	97.0	10.2	1.4	102.0	-1	75.0	-2	39
Zn	mg/l	0.010	0.0062	0.0024	0.019	-1	<0.005	-1	6
Cu	mg/l	<0.005	--	--	<0.005	-	<0.005	-	3
Mn	mg/l	0.108	0.0654	0.0103	0.283	-1	0.018	-1	46
Fe	mg/l	0.11	0.0398	0.0073	0.21	-1	0.03	-1	29
Na	mg/l	6.5	1.327	0.3831	9.5	-1	4.9	-1	12
K	mg/l	2.9	0.8585	0.2478	4.0	-1	1.9	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 52. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 2 95 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.17°	0.4306°	0.1615°	25.56°	-3	14.44°	-2	710
pH		7.495	0.391	0.000	8.7	-5	6.7	-3	32
NO_3-N	mg/l	2.18	0.6687	0.1426	3.09	-1	1.19	-1	22
PO_4-P	mg/l	0.091	0.0353	0.0071	0.143	-1	0.013	-1	24
NH_3-N	mg/l	0.074	0.0719	0.0207	0.27	-1	<0.02	-1	12
SO_4	mg/l	25.3	4.497	1.836	30.3	-1	18.4	-1	6
SiO_2	mg/l	9.9	3.119	0.6367	14.5	-1	4.7	-1	24
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	48.1	3.429	0.8084	55.0	-1	42.6	-1	18
Cl	mg/l	11.9	1.116	0.3946	14.0	-1	10.4	-1	8
Ca Hard.	mg/l	49.8	4.359	1.453	56.6	-1	44.0	-1	9
Tot. Hard.	mg/l	91.9	8.759	2.919	101.8	-1	79.0	-1	9
Cr	µg/l	95.0	11.8	1.7	100..	-4	60.0	-1	40
Zn	mg/l	0.008	0.0047	0.0017	0.013	-1	<0.005	-1	6
Cu	mg/l	<0.005	--	---	<0.005	-	<0.005	-	3
Mn	mg/l	0.156	0.1592	0.0219	0.98	-1	<0.005	-3	53
Fe	mg/l	0.12	0.0837	0.0155	0.35	-1	0.02	-1	29
Na	mg/l	7.8	3.065	0.8848	15.1	-1	5.0	-1	12
K	mg/l	3.0	0.9555	0.2758	4.7	-1	1.9	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 53. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 3 50 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.27°	3.619°	0.1356°	25.56°	-4	14.44°	-2	711
pH		7.631	0.461	0.000	8.9	-5	6.7	-4	32
NO_3-N	mg/l	2.03	0.6981	0.1488	3.15	-1	0.96	-1	22
PO_4-P	mg/l	0.081	0.0401	0.0081	0.160	-2	0.010	-1	24
NH_3-N	mg/l	0.095	0.0693	0.0200	0.28	-1	<0.02	-1	12
SO_4	mg/l	24.2	3.326	1.358	27.6	-1	19.1	-1	6
SiO_2	mg/l	9.0	3.985	0.8135	14.7	-1	1.3	-1	24
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	50.6	4.458	1.023	59.0	-1	44.0	-2	19
Cl	mg/l	11.1	1.481	0.5236	12.6	-1	8.6	-1	8
Ca Hard.	mg/l	48.5	2.965	0.9883	53.0	-1	42.2	-1	9
Tot. Hard.	mg/l	82.3	12.34	4.112	98.0	-1	61.0	-1	9
Cr	µg/l	50.0	6.5	1.0	70.0	-1	35.0	-1	40
Zn	mg/l	0.009	0.0022	--	0.012	-1	0.005	-1	6
Cu	mg/l	<0.005	--	--	<0.005	-	<0.005	-	3
Mn	mg/l	0.091	0.0724	0.0114	0.299	-1	0.018	-2	40
Fe	mg/l	0.13	0.0469	0.0087	0.25	-1	0.04	-1	29
Na	mg/l	7.9	3.616	1.044	17.4	-1	5.0	-1	12
K	mg/l	3.2	1.361	0.3930	6.0	-1	1.9	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 54. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 7 49 µg/1 Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	20.44°	4.846°	0.1827°	25.00°	-2	15.00°	-4	713
pH		7.479	0.472	0.000	8.9	-1	6.7	-2	32
NO_3-N	mg/1	2.23	0.5715	0.1218	3.19	-1	1.37	-1	22
PO_4-P	mg/1	0.081	0.0339	0.0069	0.134	-1	0.010	-1	24
NH_3-N	mg/1	0.092	0.0745	0.0215	0.24	-1	<0.02	-1	12
SO_4	mg/1	24.2	4.133	1.687	28.9	-1	17.9	-1	6
SiO_2	mg/1	8.8	3.559	0.7267	14.6	-1	2.17	-1	24
Alk-P	mg/1	—	—	—	—		—		—
Alk-MO	mg/1	46.8	3.703	0.8494	53.8	-1	40.0	-1	19
Cl	mg/1	12.2	1.536	0.5431	15.2	-1	10.6	-1	8
Ca Hard.	mg/1	45.6	3.521	1.174	58.0	-1	44.0	-1	9
Tot. Hard.	mg/1	82.3	4.823	1.608	90.0	-1	76.8	-1	9
Cr	µg/1	49.0	1.0	0.0	65.0	-1	35.0	-2	40
Zn	mg/1	0.008	0.0048	0.0017	0.013	-1	<0.005	-1	6
Cu	mg/1	<0.005	—	—	0.005	-1	<0.005	-2	3
Mn	mg/1	0.089	0.0663	0.0103	0.310	-1	0.011	-1	41
Fe	mg/1	0.13	0.0663	0.0123	0.28	-1	0.03	-1	29
Na	mg/1	7.2	2.203	0.6359	12.2	-1	5.0	-1	12
K	mg/1	3.2	1.168	0.3241	5.6	-1	1.9	-1	13
Daylength		13'05"			13'44"		12'26"		32

Table 55. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.44°	3.674°	0.1378°	26.11°	-2	14.44°	-2	707
pH		7.829	0.465	0.000	9.0	-8	6.6	-1	32
NO_3-N	mg/l	1.98	0.7205	0.1536	3.21	-1	1.12	-1	22
PO_4-P	mg/l	0.089	0.0416	0.0085	0.166	-1	0.011	-1	24
NH_3-N	mg/l	0.093	0.0814	0.0235	0.29	-1	<0.02	-2	12
SO_4	mg/l	23.9	3.713	1.516	28.3	-1	19.1	-1	6
SiO_2	mg/l	9.4	3.447	0.7037	14.6	-2	1.8	-1	24
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	47.3	2.858	0.6557	53.2	-1	44.0	-1	19
Cl	mg/l	11.8	0.9588	0.3389	13.0	-1	10.0	-1	8
Ca Hard.	mg/l	47.1	4.273	1.424	56.0	-1	42.4	-1	9
Tot. Hard.	mg/l	85.4	5.505	1.835	92.0	-1	<8.0	-1	9
Cr	mg/l	<0.01	—	—	<0.01	-	<0.01	-	8
Zn	mg/l	0.011	0.0036	0.0014	0.015	-1	<0.005	-1	6
Cu	mg/l	<0.005	—	—	<0.005	-	<0.005	-	3
Mn	mg/l	0.135	0.1792	0.0287	0.810	-2	<0.005	-2	39
Fe	mg/l	0.11	0.0553	0.0102	0.19	-1	0.02	-1	29
Na	mg/l	6.7	1.639	0.4734	9.4	-1	5.0	-1	12
K	mg/l	3.6	1.591	0.4593	6.5	-1	1.8	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 56. SUMMARY CHART - CHROMIUM 3-27-72/4-27-72
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	20.50°	3.618°	0.1360°	25.00°	-2	14.44°	-1	704
pH		7.847	0.400	0.000	9.0	-5	6.8	-1	32
NO_3-N	mg/1	2.02	0.7023	0.1497	3.21	-1	0.96	-1	22
PO_4-P	mg/1	0.094	0.0464	0.0094	0.152	-1	0.007	-1	24
NH_3-N	mg/1	0.085	0.0632	0.0173	0.127	-2	<0.02	-2	12
SO_4	mg/1	23.9	3.643	1.487	27.0	-1	18.0	-1	6
SiO_2	mg/1	9.3	3.168	0.6466	14.7	-1	3.2	-1	24
Alk-P	mg/1	—	—	—	—		—		—
Alk-MO	mg/1	48.7	3.581	0.8215	57.0	-1	43.0	-1	19
Cl	mg/1	12.3	1.984	0.6887	15.0	-2	10.0	-1	8
Ca Hard.	mg/1	49.7	3.739	1.246	58.0	-1	44.8	-1	9
Tot. Hard.	mg/1	81.4	15.32	5.105	98.0	-1	45.2	-1	9
Cr	mg/1	<0.01	—	—	<0.01	-	<0.01	-	8
Zn	mg/1	0.011	0.0039	0.0014	0.015	-1	0.005	-1	6
Cu	mg/1	<0.005	—	—	<0.005	-	<0.005	-	3
Mn	mg/1	0.093	0.0863	0.0139	0.440	-1	<0.005	-2	38
Fe	mg/1	0.11	0.0413	0.0077	0.17	-1	0.02	-1	28
Na	mg/1	6.7	1.777	0.5129	10.1	-1	4.9	-1	12
K	mg/1	3.4	1.128	0.3257	5.1	-1	1.8	-1	12
Daylength		13'05"			13'44"		12'26"		32

Table 57. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 1 407 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.83°	5.24°	0.272°	22.22° -3	12.78° -1	371
pH		7.734	0.360	0.017	8.9 -7	6.9 -3	17
NO_3-N	mg/l	2.36	0.1202	0.0347	2.59 -1	2.15 -1	12
PO_4-P	mg/l	0.070	0.0262	0.0072	0.108 -1	0.031 -1	13
NH_3-N	mg/l	0.157	0.0924	0.0349	0.360 -1	0.089 -1	7
SO_4	mg/l	19.2	--	--	--	--	1
SiO_2	mg/l	13.1	0.5964	0.1798	13.8 -2	11.8 -1	11
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	52.1	1.606	0.5079	56.0 -1	50.0 -1	10
Cl	mg/l	8.7	2.334	1.167	11.8 -1	6.2 -1	4
Ca Hard.	mg/l	47.5	1.346	0.6019	49.2 -1	45.6 -1	5
Tot. Hard.	mg/l	90.4	--	--	94.0 -1	86.8 -1	2
Cr	µg/l	407.0	12.9	3.3	430.0 -2	390.0 -2	15
Zn	mg/l	0.012	--	--	0.013 -1	0.010 -1	2
Cu	mg/l	<0.005	--	--	--	--	1
Mn	mg/l	0.148	0.0626	0.0152	0.277 -1	0.072 -1	17
Fe	mg/l	0.15	0.0544	0.0151	0.23 -2	0.07 -1	13
Na	mg/l	5.0	0.4412	0.1801	5.7 -1	4.6 -2	6
K	mg/l	2.2	0.1113	0.0420	2.4 -1	2.1 -2	7
Daylength		14'27"			14'13"	14'40"	

Table 58. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 5 403 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.94°	4.218 °	0.223°	21.67° -2	10.00° -1	371
pH		7.717	0.308	0.014	8.6 -4	6.9 -2	17
NO_3-N	mg/l	2.50	0.1472	0.0425	2.74 -1	2.21 -1	12
PO_4-P	mg/l	0.068	0.0247	0.0068	0.106 -1	0.033 -2	13
NH_3-N	mg/l	0.136	0.0898	0.0339	0.310 -1	0.044 -1	7
SO_4	mg/l	18.7	--	--	--	--	1
SiO_2	mg/l	13.3	0.4081	0.1230	13.8 -2	12.7 -2	11
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	52.3	1.673	0.5292	54.8 -1	49.0 -1	10
Cl	mg/l	11.0	1.869	0.9345	13.0 -1	8.8 -1	4
Ca Hard.	mg/l	50.8	1.924	0.8602	54.0 -1	49.0 -1	5
Tot. Hard.	mg/l	83.7	--	--	84.2 -1	83.2 -1	2
Cr	µg/l	403.0	14.0	3.5	435.0 -1	385.0 -2	16
Zn	mg/l	0.011	--	--	0.018 -1	0.008 -2	3
Cu	mg/l	<0.005	--	--	--	--	1
Mn	mg/l	0.127	0.0811	0.0191	0.266 -1	0.021 -1	18
Fe	mg/l	0.16	0.0459	0.0122	0.23 -1	0.09 -1	14
Na	mg/l	5.1	0.4997	0.2039	5.9 -1	4.6 -2	6
K	mg/l	2.3	0.1574	0.0595	2.5 -2	2.1 -1	7
Daylength		14'27"			14'13"	14'40"	

Table 59. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72

Test 2 100 µg/l

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	15.94°	4.433°	0.229°	22.22° -3	10.56° -1	372
pH		7.622	0.357	0.017	8.7 -5	6.9 -2	17
NO_3-N	mg/l	2.24	0.1728	0.0499	2.45 -1	1.94 -1	12
PO_4-P	mg/l	0.069	0.026	0.0072	0.117 -1	0.026 -1	13
NH_3-N	mg/l	0.163	0.1011	0.0382	0.378 -1	0.080 -1	7
SO_4	mg/l	18.8	--	--	--	--	1
SiO_2	mg/l	11.0	1.644	0.4956	13.1 -1	8.2 -1	11
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	51.5	1.520	0.4808	54.4 -1	49.4 -1	10
Cl	mg/l	9.6	2.078	1.039	11.8 -1	7.0 -1	4
Ca Hard.	mg/l	48.2	1.571	0.7026	50.8 -1	46.8 -1	5
Tot. Hard.	mg/l	86.5	--	--	91.0 -1	82.0 -1	2
Cr	µg/l	100.0	5.7	1.4	110.0 -2	90.0 -1	15
Zn	mg/l	0.008	--	--	0.010 -1	0.006 -1	3
Cu	mg/l	<0.005	--	--	--	--	1
Mn	mg/l	0.119	0.0648	0.0149	0.236 -2	0.022 -1	19
Fe	mg/l	0.14	0.0533	0.0142	0.24 -2	0.07 -1	14
Na	mg/l	5.1	0.5357	0.2187	5.8 -1	4.5 -1	6
K	mg/l	2.1	0.1134	0.0428	2.2 -1	1.9 -2	7
Daylength		14'27"			14'13"	14'40"	

Table 60. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 6 99 µg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.11°	4.327°	0.229°	21.67° -4	10.00° -1	372
pH		7.592	0.358	0.017	8.6 -7	6.9 -3	17
NO_3-N	mg/l	2.29	0.1741	0.0502	2.51 -1	1.93 -1	12
PO_4-P	mg/l	0.074	0.0242	0.0067	0.103 -1	0.033 -1	13
NH_3-N	mg/l	0.140	0.0801	0.0303	0.306 -1	0.066 -1	7
SO_4	mg/l	19.0	—	—	—	—	1
SiO_2	mg/l	11.2	1.716	0.5173	13.2 -1	8.4 -1	11
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	53.2	2.789	0.8818	58.0 -1	50.0 -1	10
Cl	mg/l	11.3	0.5972	0.2986	12.0 -1	10.6 -1	4
Ca Hard.	mg/l	49.3	2.212	0.9891	51.6 -1	46.2 -1	5
Tot. Hard.	mg/l	86.2	—	—	87.0 -1	85.4 -1	2
Cr	µg/l	99.0	4.9	1.0	110.0 -1	90.0 -1	15
Zn	mg/l	0.010	—	—	0.013 -1	0.008 -1	3
Cu	mg/l	<0.005	—	—	—	—	1
Mn	mg/l	0.094	0.0506	0.0116	0.208 -1	0.014 -1	19
Fe	mg/l	0.14	0.0496	0.0132	0.23 -1	0.05 -1	14
Na	mg/l	5.1	0.5947	0.2428	6.0 -1	4.6 -2	6
K	mg/l	2.1	0.1033	0.0422	2.2 -1	1.9 -1	6
Daylength		14'27"			14'13"	14'40"	

Table 61. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 3 49 µg/l Cr

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.00°	4.387°	0.227°	22.22° -1	10.56° -1	371
pH		7.60	0.378	0.017	9.0 -2	6.9 -4	17
NO_3-N	mg/l	2.16	0.2495	0.0720	2.48 -1	1.72 -1	12
PO_4-P	mg/l	0.068	0.0237	0.0066	0.106 -1	0.033 -2	13
NH_3-N	mg/l	0.150	0.0899	0.0340	0.344 -1	0.076 -1	7
SO_4	mg/l	19.4	--	--	--	--	1
SiO_2	mg/l	9.9	1.833	0.5526	12.7 -1	7.2 -1	11
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	50.9	1.624	0.5136	54.0 -1	48.6 -1	10
Cl	mg/l	12.4	5.262	2.631	20.0 -1	8.0 -1	4
Ca Hard.	mg/l	50.9	2.532	1.132	53.6 -1	47.0 -1	5
Tot. Hard.	mg/l	94.3	--	--	99.0 -1	89.6 -1	2
Cr	µg/l	49.0	4.8	1.0	60.0 -1	40.0 -1	15
Zn	mg/l	0.009	--	--	0.010 -2	0.008 -1	3
Cu	mg/l	<0.005	--	--	--	--	1
Mn	mg/l	0.167	0.1277	0.0293	0.448 -1	0.030 -1	19
Fe	mg/l	0.13	0.0547	0.0146	0.23 -1	0.07 -4	14
Na	mg/l	5.4	1.303	0.5321	7.9 -1	4.6 -2	6
K	mg/l	2.1	0.3132	0.1184	2.8 -1	1.9 -2	7
Daylength		14'27"			14'13"	14'40"	

Table 62. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 7 49 μg/l Cr

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.11°	4.440°	0.243°	22.22° -1	10.06° -2	371
pH		7.575	0.512	0.024	9.0 -1	6.9 -3	17
NO_3-N	mg/l	2.04	0.3119	0.0900	2.39 -2	1.48 -1	12
PO_4-P	mg/l	0.064	0.0237	0.0066	0.103 -1	0.033 -3	13
NH_3-N	mg/l	0.131	0.0815	0.0308	0.296 -1	0.059 -1	7
SO_4	mg/l	19.2	—	—	—	—	1
SiO_2	mg/l	9.0	2.432	0.7334	12.8 -1	5.4 -1	11
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	55.3	6.116	1.934	71.0 -1	50.0 -2	10
Cl	mg/l	11.4	1.237	0.6185	12.4 -1	9.6 -1	4
Ca Hard.	mg/l	48.6	1.920	0.8588	51.0 -1	45.8 -1	5
Tot. Hard.	mg/l	88.1	—	—	91.6 -1	84.6 -1	2
Cr	μg/l	49.0	4.2	1.0	60.0 -1	45.0 -6	15
Zn	mg/l	0.014	—	—	0.018 -1	0.010 -1	3
Cu	mg/l	<0.005	—	—	—	—	1
Mn	mg/l	0.153	0.1199	0.0275	0.496 -1	0.018 -1	19
Fe	mg/l	0.12	0.0497	0.0133	0.22 -1	0.07 -2	14
Na	mg/l	5.3	1.302	0.5315	7.8 -1	4.5 -1	6
K	mg/l	2.3	0.3401	0.1286	2.9 -1	1.9 -1	7
Daylength		14'27"			14'13"	14'40"	

Table 63. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.00°	4.40°	0.228°	22.22° -3	10.56° -1	371
pH		7.90	0.403	0.020	9.1 -1	7.0 -1	17
NO_3-N	mg/l	1.91	0.3506	0.1012	2.37 -1	1.36 -1	12
PO_4-P	mg/l	0.058	0.0226	0.0062	0.117 -1	0.025 -1	13
NH_3-N	mg/l	0.148	0.0875	0.0331	0.340 -1	0.089 -1	7
SO_4	mg/l	19.5	--	--	--	--	1
SiO_2	mg/l	8.1	2.918	0.8798	12.7 -1	3.8 -1	11
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	53.0	4.207	1.330	59.0 -1	48.0 -1	10
Cl	mg/l	9.8	2.007	1.003	12.0 -1	8.0 -1	4
Ca Hard.	mg/l	50.9	2.143	0.9583	54.2 -1	49.0 -2	5
Tot. Hard.	mg/l	81.0	--	--	82.6 -1	79.4 -1	2
Cr	mg/l	<0.01	--	--	<0.01	<0.01	5
Zn	mg/l	0.013	--	--	0.016 -1	0.011 -1	3
Cu	mg/l	<0.005	--	--	--	--	1
Mn	mg/l	0.173	0.1272	0.0292	0.432 -1	0.026 -1	19
Fe	mg/l	0.13	0.0519	0.0139	0.23 -1	0.06 -2	14
Na	mg/l	5.4	1.323	0.5400	7.9 -1	4.5 -1	6
K	mg/l	2.2	0.2819	0.1066	2.7 -1	1.9 -1	7
Daylength		14'27"			14'13"	14'40"	

Table 64. SUMMARY CHART - CHROMIUM 5-11-72/5-26-72
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.06°	4.299°	0.229°	21.67° -4	10.00° -1	371
pH		7.833	0.407	0.020	8.8 -1	6.8 -1	17
NO_3-N	mg/1	1.94	0.3901	0.1126	2.55 -1	1.29 -1	12
PO_4-P	mg/1	0.062	0.0257	0.0071	0.108 -1	0.027 -1	13
NH_3-N	mg/1	0.149	0.1034	0.0391	0.376 -1	0.072 -1	7
SO_4	mg/1	19.4	--	--	--	--	1
SiO_2	mg/1	8.9	2.357	0.7108	12.9 -1	6.0 -1	11
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	53.4	3.391	1.072	59.4 -1	49.8 -1	10
Cl	mg/1	10.6	1.925	0.9626	13.0 -1	8.4 -1	4
Ca Hard.	mg/1	48.9	1.196	0.8569	51.4 -1	47.0 -2	5
Tot. Hard.	mg/1	89.0	--	--	95.0 -1	83.0 -1	2
Cr	mg/1	<0.01	--	--	< 0.01 -	<0.01 -	5
Zn	mg/1	0.011	--	--	0.016 -1	0.008 -1	3
Cu	mg/1	<0.005	--	--	--	--	1
Mn	mg/1	0.207	0.1424	0.0326	0.547 -1	0.030 -1	19
Fe	mg/1	0.13	0.0487	0.0130	0.22 -2	0.05 -1	14
Na	mg/1	5.3	1.229	0.5019	7.6 -1	4.5 -2	6
K	mg/1	2.5	0.4618	0.1745	3.2 -1	2.1 -2	7
Daylength		14'27"			14'13"	14'40"	

Table 65. SUMMARY CHART - CHROMIUM 6-30-72/7-21-72
Test 6 0.398 mg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.72°	--	--	20.56° -3	11.11° -1	19
pH		7.883	0.373	0.014	8.6 -7	7.0 -8	19
NO_3-N	mg/l	2.72	0.3136	0.0869	2.95 -1	1.78 -1	13
PO_4-P	mg/l	0.028	0.0161	0.0032	0.083 -1	0.017 -1	14
NH_3-N	mg/l	0.084	0.0709	0.0249	0.188 -1	< 0.02 -2	8
SO_4	mg/l	17.1	--	--	18.0 -1	16.3 -1	3
SiO_2	mg/l	14.1	2.369	0.6569	15.6 -4	8.2 -1	13
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	51.9	2.419	0.6709	54.6 -1	46.0 -1	13
Cl	mg/l	9.1	--	--	10.0 -1	8.23 -1	2
Ca Hard.	mg/l	47.4	--	--	48.2 -1	47.0 -2	3
Tot. Hard.	mg/l	81.4	--	--	82.2 -1	80.0 -1	3
Cr	mg/l	0.398	0.0900	0.0176	0.546 -1	0.00 -1	26
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.043	0.0235	0.0045	0.103 -1	0.009 -1	20
Fe	mg/l	0.28	0.3736	0.0998	1.57 -1	0.13 -2	14
Na	mg/l	5.1	0.1976	0.0746	5.4 -1	4.9 -1	7
K	mg/l	2.4	0.2582	0.0976	2.9 -1	2.1 -1	7
Daylength		14'47"			14'58"	14'34"	

Table 66. SUMMARY CHART - CHROMIUM 6-30-72/7-21-72
Test 7 0.380 mg/l Cr

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.72°	--	--	20.56° -2	11.11° -1	19
pH		7.764	0.336	0.014	8.8 -4	7.0 -3	19
NO_3-N	mg/l	2.76	0.3319	0.0920	3.03 -1	1.78 -1	13
PO_4-P	mg/l	0.033	0.0319	0.0084	0.142 -1	0.015 -1	14
NH_3-N	mg/l	0.089	0.0744	0.0263	0.216 -1	$<$0.02 -1	8
SO_4	mg/l	17.1	--	--	17.8 -1	16.3 -1	3
SiO_2	mg/l	13.8	2.413	0.6693	15.64 -1	7.5 -1	13
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	51.8	3.152	0.8741	57.0 -1	46.0 -1	13
Cl	mg/l	8.5	--	--	8.9 -1	8.0 -1	2
Ca Hard.	mg/l	52.3	--	--	57.0 -1	47.0 -1	3
Tot. Hard.	mg/l	83.4	--	--	91.0 -1	76.2 -1	3
Cr	mg/l	0.380	0.0909	0.0176	0.596 -1	0.00 -1	26
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.027	0.0197	0.0032	0.086 -1	0.011 -1	20
Fe	mg/l	0.30	0.4055	0.1124	1.64 -1	0.13 -1	13
Na	mg/l	5.1	0.3147	0.1189	5.6 -1	4.7 -1	7
K	mg/l	2.4	0.2582	0.0976	2.9 -1	2.1 -1	7
Daylength		14'47"			14'58"	14'34"	

Table 67. SUMMARY CHART - CHROMIUM 6-30-72/7-21-72
Test 8 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.67°	---	---	20.56° -2	10.56° -1	19
pH		7.825	0.506	0.022	8.9 -1	7.0 -12	19
NO_3-N	mg/l	2.83	0.4103	0.1138	3.59 -1	1.81 -1	13
PO_4-P	mg/l	0.027	0.0148	0.0032	0.078 -1	0.017 -1	14
NH_3-N	mg/l	0.085	0.0836	0.0295	0.232 -1	<0.02 -2	8
SO_4	mg/l	17.4	---	---	18.1 -1	16.7 -1	3
SiO_2	mg/l	13.7	2.452	0.6801	15.7 -1	6.9 -1	13
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	51.5	2.814	0.7804	56.6 -1	48.8 -1	13
Cl	mg/l	9.6	---	---	10.1 -1	9.0 -1	2
Ca Hard.	mg/l	50.7	---	---	58.2 -1	46.2 -1	3
Tot. Hard.	mg/l	79.8	---	---	84.0 -1	77.6 -1	3
Cr	mg/l	0.0	---	---	0.0 -	0.0 -	17
Zn	mg/l	---	---	---	---	---	---
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.027	0.0187	0.0032	0.079 -1	0.013 -1	19
Fe	mg/l	0.31	0.4067	0.1174	1.59 -1	0.13 -1	12
Na	mg/l	5.1	0.3450	0.1304	5.5 -1	4.5 -1	7
K	mg/l	2.1	0.2673	0.1009	2.6 -1	1.8 -1	7
Daylength		14'47"			14'58"	14'34"	

Table 68. SUMMARY CHART - CHROMIUM 7-28-72/8-17-72
Test 8 0.4 mg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.22°	3.008°	0.186°	20.56°	-2	12.22°	-2	261
pH		7.766	0.398	0.017	9.0	-1	7.1	-1	21
NO_3-N	mg/l	2.71	0.1789	0.0800	2.97	-1	2.55	-1	5
PO_4-P	mg/l	0.035	0.0114	0.0046	0.049	-1	0.021	-1	6
NH_3-N	mg/l	0.089	--	--	0.150	-1	0.058	-1	3
SO_4	mg/l	17.6	--	--	17.6	-	17.6	-	1
SiO_2	mg/l	15.6	0.9626	0.3929	17.0	-1	14.1	-1	6
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	57.2	2.916	1.190	60.8	-1	53.0	-1	6
Cl	mg/l	8.0	--	--	8.0	-	8.0	-	1
Ca Hard.	mg/l	51.4	--	--	52.6	-1	50.2	-1	2
Tot. Hard.	mg/l	81.2	--	--	81.6	-1	80.8	-1	2
Cr	mg/l	0.40	0.0107	0.0040	0.40	-1	0.39	-1	7
Zn	mg/l	0.011	--	--	0.011	-	0.011	-	1
Cu	mg/l	0.01	--	--	0.01	-	0.01	-	1
Mn	mg/l	0.189	0.1083	0.0409	0.332	-1	0.027	-1	7
Fe	mg/l	0.11	0.0366	0.0149	0.16	-1	0.07	-1	6
Na	mg/l	5.5	0.1000	0.0577	5.6	-1	5.4	-1	3
K	mg/l	2.3	0.0577	0.0333	2.3	-2	2.2	-1	3
Daylength		14'03"			14'23"		13'41"		21

Table 69. SUMMARY CHART - CHROMIUM 7-28-72/8-17-72
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.33°	3.314°	0.150°	22.78° -1	13.33° -1	489
pH		7.691	0.341	0.014	8.9 -1	6.8 -1	21
NO_3-N	mg/1	2.34	0.2977	0.0825	2.85 -1	2.07 -2	13
PO_4-P	mg/1	0.063	0.0257	0.0063	0.110 -1	0.026 -1	14
NH_3-N	mg/1	0.078	0.0416	0.0145	0.160 -1	0.020 -1	8
SO_4	mg/1	21.8	--	--	25.6 -1	16.9 -1	3
SiO_2	mg/1	11.3	2.252	0.6019	14.7 -1	6.7 -1	14
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	53.2	2.141	0.5723	57.6 -1	50.0 -2	14
Cl	mg/1	9.2	--	--	9.8 -1	8.8 -1	3
Ca Hard.	mg/1	52.2	--	--	54.0 -1	51.0 -1	3
Tot. Hard.	mg/1	80.7	--	--	81.0 -1	80.2 -1	3
Rb	mg/1	0.00	--	--	0.00 -	0.00 -	17
Zn	mg/1	0.010	--	--	0.010 -	0.010 -	1
Cu	mg/1	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/1	0.146	0.1507	0.0307	0.640 -1	0.012 -1	24
Fe	mg/1	0.14	0.0538	0.0138	0.25 -1	0.07 -1	15
Na	mg/1	5.9	0.6610	0.2337	7.2 -1	5.1 -1	8
K	mg/1	2.1	0.1807	0.0639	2.4 -1	1.9 -2	8
Daylength		14'03"			14'23"	13'41"	21

Table 70. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 1 40.8 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.78°	4.3°	0.16°	20.56°-1	8.33°-1	31
pH		7.554	0.466	0.914	7.9 -2	6.7 -2	31
NO_3-N	mg/l	2.82	0.1373	0.0307	3.09 -1	2.54 -1	20
PO_4-P	mg/l	0.088	0.0361	0.0084	0.308-1	0.031-1	17
NH_3-N	mg/l	0.079	0.0498	0.0138	0.162-1	<0.02 -2	13
SO_4	mg/l	15.8	0.9659	0.4319	17.0 -1	14.9 -1	5
SiO_2	mg/l	14.8	1.781	0.3797	17.1 -1	11.2 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	35.9	5.076	1.082	48.4 -1	31.0 -2	22
Cl	mg/l	9.5	0.8556	0.3826	10.6 -1	8.4 -1	5
Ca Hard.	mg/l	59.1	4.229	1.892	62.0 -2	51.8 -1	5
Tot. Hard.	mg/l	85.2	4.786	2.140	91.8 -1	78.4 -1	5
Se	mg/l	40.8	0.9252	0.1814	42.8 -1	39.0 -1	26
Zn	mg/l	0.0036	--	--	0.0050-2	0.0014-1	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.154	0.0609	0.0114	0.270-1	0.029-1	28
Fe	mg/l	0.12	0.0429	0.0084	0.26 -1	0.08 -3	25
Na	mg/l	5.8	0.4442	0.1282	6.5 -1	4.9 -1	12
K	mg/l	2.3	0.3315	0.0957	3.1 -1	2.0 -2	12
Daylength		11'37"			12'15"	10'59"	

Table 71. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 2 20.9 mg/l Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.89°	4.44°	0.17 °	20.56°-1	8.33°-1	31
pH		7.617	0.173	0.000	8.4 -3	6.7 -1	31
NO_3-N	mg/l	2.72	0.1766	0.0394	2.95 -1	2.41 -1	20
PO_4-P	mg/l	0.092	0.0391	0.0077	0.522-1	0.047-1	17
NH_3-N	mg/l	0.078	0.0419	0.0114	0.168-1	<0.02 -1	13
SO_4	mg/l	15.8	1.006	0.4499	17.4 -1	14.9 -1	5
SiO_2	mg/l	14.4	2.781	0.5929	17.8 -1	7.0 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	47.5	6.026	1.285	56.8 -1	26.4 -1	22
Cl	mg/l	10.4	0.9209	0.4118	12.0 -1	9.8 -1	5
Ca Hard.	mg/l	57.0	7.555	3.379	66.0 -1	50.4 -1	5
Tot. Hard.	mg/l	85.6	5.387	2.409	94.0 -1	79.2 -1	5
Se	mg/l	20.9	1.187	0.2328	23.8 -1	18.4 -1	26
Zn	mg/l	0.0017	--	--	0.0030-1	0.0004-1	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.139	0.0731	0.0138	0.391-1	0.035-1	28
Fe	mg/l	0.13	0.0488	0.0095	0.31 -1	0.08 -3	25
Na	mg/l	5.7	0.5941	0.1715	6.6 -1	4.3 -1	12
K	mg/l	2.3	0.3502	0.1011	3.1 -1	2.0 -3	12
Daylength		11'37"			12'15"	10'59"	

Table 72. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 3 10.6 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD $\pm$	SE $\pm$	Maximum	Minimum	N
Temp.	°C	14.72°	4.32°	0.16°	20.56°-1	8.33°-1	31
pH		7.575	0.315	0.010	8.7 -1	6.5 -1	31
NO_3-N	mg/l	2.63	0.2392	0.0535	3.13 -1	2.26 -1	20
PO_4-P	mg/l	0.063	0.0241	0.0055	0.160-1	0.036-2	17
NH_3-N	mg/l	0.082	0.0466	0.0126	0.186-1	<0.02 -1	13
SO_4	mg/l	16.4	1.374	0.6143	18.1 -1	14.9 -1	5
SiO_2	mg/l	13.8	2.626	0.5598	17.8 -1	9.4 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	54.5	5.671	1.209	74.7 -1	47.2 -1	22
Cl	mg/l	10.0	0.5831	0.2608	10.6 -1	9.2 -1	5
Ca Hard.	mg/l	57.4	7.779	3.479	69.2 -1	51.2 -1	5
Tot. Hard.	mg/l	88.9	6.743	3.016	99.8 -1	83.2 -1	5
Se	mg/l	10.6	0.5329	0.1044	11.7 -1	9.5 -1	26
Zn	mg/l	0.0012	--	--	0.0023-1	0.0005-2	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.149	0.1065	0.0200	0.391-1	0.046-1	28
Fe	mg/l	0.12	0.0412	0.0077	0.23 -1	0.06 -2	25
Na	mg/l	5.9	0.6887	0.1988	7.3 -1	4.8 -1	12
K	mg/l	2.3	0.3397	0.0980	3.0 -1	2.0 -4	12
Daylength		11'37"			12'15"	10'59"	

Table 73. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 4 5.4 mg/l Selenite

Chemical or physical analysis	$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp. °C	15.28°	4.29°	0.16°	21.11°-1	8.89°-1	31
pH	7.833	0.256	0.000	8.7 -3	7.1 -9	31
NO_3-N mg/l	2.43	0.2748	0.0614	2.95 -1	1.94 -1	20
PO_4-P mg/l	0.052	0.0401	0.0084	0.150-1	0.010-1	21
NH_3-N mg/l	0.083	0.1377	0.0100	0.149-1	0.027-1	13
SO_4 mg/l	18.8	4.240	1.896	23.7 -1	15.1 -1	5
SiO_2 mg/l	12.2	2.917	0.6197	17.9 -1	6.4 -1	22
Alk-P mg/l	--	--	--	--	--	--
Alk-MO mg/l	55.2	4.496	0.9586	63.8 -1	44.8 -1	22
Cl mg/l	9.3	0.7949	0.3555	10.0 -1	8.0 -1	5
Ca Hard. mg/l	60.3	6.466	0.2892	70.0 -1	52.8 -1	5
Tot. Hard. mg/l	80.9	10.78	4.819	98.4 -1	68.8 -1	5
Se mg/l	5.4	0.3788	0.0742	6.3 -1	4.7 -1	26
Zn mg/l	0.00065	--	--	0.0016-1	<0.0005-1	4
Cu mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn mg/l	0.104	0.1002	0.0187	0.390-1	0.006-1	28
Fe mg/l	0.14	0.0784	0.0155	0.36 -1	0.05 -2	25
Na mg/l	5.9	0.5549	0.1602	7.1 -1	5.3 -1	12
K mg/l	2.4	0.3423	0.0988	3.0 -1	2.0 -2	12
Daylength	11'37"			12'15"	10'59"	

Table 74. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 5 2.6 mg/l Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.39°	3.179°	0.124°	18.89°-1	8.89°-1	31
pH		7.742	0.407	0.014	8.8 -2	7.0 -17	31
NO_3-N	mg/l	2.57	0.1914	0.0483	2.95 -1	2.30 -1	19
PO_4-P	mg/l	0.005	0.0302	0.0063	0.104-1	0.016-1	21
NH_3-N	mg/l	0.073	0.0401	0.0114	0.148-1	0.027-1	12
SO_4	mg/l	18.9	3.952	1.767	23.2 -1	14.6 -1	5
SiO_2	mg/l	13.3	2.528	0.5390	16.8 -1	6.1 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	56.1	5.036	1.074	65.6 -1	46.0 -1	22
Cl	mg/l	8.8	0.9317	0.4167	10.0 -1	7.8 -1	5
Ca Hard.	mg/l	56.2	3.140	1.404	59.8 -1	51.8 -1	5
Tot. Hard.	mg/l	87.0	8.903	3.982	102.4 -1	80.2 -1	5
Se	mg/l	2.6	0.2210	0.0432	3.2 -1	2.0 -1	26
Zn	mg/l	0.0012	--	--	0.0021-1	0.0004-1	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.139	0.1356	0.0255	0.690-1	0.020-1	28
Fe	mg/l	0.13	0.0670	0.0130	0.35 -1	0.05 -1	25
Na	mg/l	5.8	0.6156	0.1777	7.1 -1	5.2 -1	12
K	mg/l	2.3	0.3846	0.1111	3.1 -1	1.9 -1	12
Daylength		11'37"			12'15"	10'59"	

Table 75. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 6 1.0 mg/l Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.50°	3.137°	0.122°	18.89°-1	8.89°-1	31
pH		7.866	0.310	0.010	9.0 -2	7.0 -23	31
NO_3-N	mg/l	2.46	0.2129	0.0475	2.96 -1	2.17 -2	20
PO_4-P	mg/l	0.054	0.0316	0.0063	0.103-1	0.017-2	21
NH_3-N	mg/l	0.079	0.0463	0.0126	0.168-1	<0.02 -2	13
SO_4	mg/l	18.7	3.124	1.352	22.5 -1	15.2 -1	5
SiO_2	mg/l	12.3	3.083	0.6572	17.3 -1	5.6 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	56.5	2.807	0.5984	60.2 -1	51.4 -1	22
Cl	mg/l	9.2	0.6325	0.2828	9.8 -1	8.2 -1	5
Ca Hard.	mg/l	56.6	4.297	1.921	62.6 -1	52.0 -1	5
Tot. Hard.	mg/l	85.2	8.737	3.907	100.0 -1	78.8 -1	5
Se	mg/l	1.04	0.0859	0.0167	1.24 -1	0.90 -2	26
Zn	mg/l	0.00095	--	--	<0.0020-1	0.0005-2	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.130	0.0767	0.0145	0.340-1	0.009-1	28
Fe	mg/l	0.12	0.0584	0.0114	0.31 -1	0.07 -2	25
Na	mg/l	5.95	0.4337	0.1252	6.8 -1	5.4 -1	12
K	mg/l	2.3	0.3720	0.1074	3.1 -1	2.0 -3	12
Daylength		11'37"			12'15"	10'59"	

Table 76. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 7 0.10 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.50°	3.101°	0.1207°	18.33°-3	8.89°-1	31
pH		7.712	0.439	0.014	8.8 -4	6.9 -1	31
NO_3-N	mg/l	2.46	0.2311	0.0517	2.87 -1	2.11 -1	20
PO_4-P	mg/l	0.044	0.0221	0.0045	0.083-1	0.018-1	21
NH_3-N	mg/l	0.079	0.0427	0.0118	0.154-1	<0.02 -1	13
SO_4	mg/l	18.9	3.224	1.442	22.1 -1	15.1 -1	5
SiO_2	mg/l	11.9	3.320	0.7079	17.6 -1	5.4 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	57.4	2.914	0.6213	63.2 -1	51.6 -1	22
Cl	mg/l	9.6	0.4000	0.1789	10.0 -1	9.0 -1	5
Ca Hard.	mg/l	58.9	8.889	3.976	72.6 -1	49.4 -1	5
Tot. Hard.	mg/l	88.5	11.78	5.268	109.4 -1	81.0 -1	5
Se	mg/l	0.10	0.114	0.0000	0.13 -1	0.08 -2	24
Zn	mg/l	0.00085	--	--	0.0015-1	0.0006-2	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.122	0.0920	0.0173	0.400-1	0.016-1	28
Fe	mg/l	0.12	0.0679	0.0134	0.34 -1	0.05 -2	25
Na	mg/l	5.9	0.6007	0.1734	7.1 -1	4.7 -1	12
K	mg/l	2.3	0.3728	0.1076	3.1 -1	2.0 -2	12
Daylength		11'37"			12'15"	10'59"	

Table 77. SUMMARY CHART - SELENIUM 9-20-72/10-20-72
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	14.50°	3.090°	0.1203°	18.89°-1	8.89°-1	31
pH		7.993	0.400	0.014	8.9 -7	7.1 -7	31
NO_3-N	mg/l	2.36	0.2589	0.0579	2.91 -1	1.99 -1	20
PO_4-P	mg/l	0.050	0.0389	0.0084	0.126-1	0.010-1	21
NH_3-N	mg/l	0.090	0.0536	0.0148	0.230-1	0.020-1	13
SO_4	mg/l	18.9	3.009	1.346	21.9 -1	15.4 -1	5
SiO_2	mg/l	11.9	3.624	0.7727	18.6 -1	7.9 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	56.7	3.766	0.8029	64.0 -1	48.6 -1	22
Cl	mg/l	9.6	0.8532	0.3816	10.6 -1	8.4 -1	5
Ca Hard.	mg/l	55.2	4.208	1.882	61.2 -1	50.6 -1	5
Tot. Hard.	mg/l	88.9	10.56	4.723	106.6 -1	80.4 -1	5
Se	mg/l	0.01	--	--	<0.01 -	<0.01 -	25
Zn	mg/l	0.0010	--	--	0.0015-1	0.0005-1	4
Cu	mg/l	<0.003	--	--	<0.003-	<0.003-	1
Mn	mg/l	0.128	0.1105	0.0207	0.389-1	0.012-1	28
Fe	mg/l	0.15	0.0782	0.0155	0.40 -1	0.08 -2	25
Na	mg/l	5.9	0.7158	0.2066	7.5 -1	5.3 -1	12
K	mg/l	2.4	0.3701	0.1068	3.0 -1	2.0 -2	12
Daylength		11'37"			12'15"	10'59"	

Table 78. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 1 40.9 mg/l Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	8.17°	3.429°	0.147°	12.22°-4	5.00°-3	26
pH		7.405	0.125	0.000	8.0 -1	6.9 -3	26
NO_3-N	mg/l	2.98	0.1884	0.0486	3.29 -1	2.64 -1	15
PO_4-P	mg/l	0.098	0.0228	0.0055	0.138 -1	0.064-1	14
NH_3-N	mg/l	0.117	0.0703	0.0221	0.282 -1	0.050-1	10
SO_4	mg/l	18.1	0.9192	0.4111	19.5 -1	17.0 -1	5
SiO_2	mg/l	14.3	1.661	0.4439	16.0 -2	9.7 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	32.4	3.585	0.9580	39.0 -1	26.0 -1	14
Cl	mg/l	20.6	5.827	3.365	27.0 -1	15.6 -1	3
Ca Hard.	mg/l	54.8	8.381	4.839	62.0 -1	45.6 -1	3
Tot. Hard.	mg/l	89.3	8.693	5.019	99.2 -1	82.8 -1	3
Se	mg/l	40.9	2.075	0.4423	43.3 -1	34.2 -1	22
Zn	mg/l	3.3	0.1414	0.1000	3.4 -1	3.2 -1	2
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.104	0.0311	0.0063	0.167 -1	0.049-1	21
Fe	mg/l	0.31	0.2085	0.0477	0.89 -1	0.13 -1	19
Na	mg/l	5.7	0.6523	0.2063	6.6 -1	4.8 -1	10
K	mg/l	2.96	0.5123	0.1708	4.2 -1	2.5 -1	9
Daylength		9'50"			10'12"	9'31"	

Table 79. SUMMARY CHART - ·SELENIUM 11-9-72/12-4-72
Test 5 40.3 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	7.78°	2.92°	0.13°	11.11° -2	3.33°-1	26
pH		7.645	0.382	0.014	8.5 -1	6.9 -1	26
NO_3-N	mg/l	3.01	0.1315	0.0339	3.22 -1	2.79 -1	15
PO_4-P	mg/l	0.102	0.0232	0.0055	0.127 -1	0.063 -1	14
NH_3-N	mg/l	0.087	0.0456	0.0141	1.58 -1	<0.02 -1	10
SO_4	mg/l	18.3	0.6978	0.3121	19.3 -1	17.4 -1	5
SiO_2	mg/l	13.7	2.383	0.6369	16.0 -2	6.4 -1	14
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	30.9	6.412	1.714	47.0 -1	17.0 -1	14
Cl	mg/l	17.7	5.942	3.434	24.01 -1	12.2 -1	3
Ca Hard.	mg/l	51.7	0.4163	0.2404	52.0 -1	51.2 -1	3
Tot. Hard.	mg/l	83.1	5.608	3.238	88.0 -1	77.0 -1	3
Se	mg/l	40.3	2.124	0.4528	43.3 -1	33.0 -1	22
Zn	mg/l	4.5	1.979	1.400	5.9 -1	3.1 -1	2
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.104	0.0351	0.0071	0.205 -1	0.053 -1	21
Fe	mg/l	0.32	0.1906	0.0437	0.82 -1	0.16 -2	19
Na	mg/l	5.6	0.6689	0.2229	6.7 -1	4.7 -1	9
K	mg/l	3.0	0.4944	0.1648	4.2 -1	2.5 -1	9
Daylength		9'50"			10'12"	9'31"	

Table 80. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 2 10.4 mg/1 Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	8.17°	3.429°	0.147°	12.22° -4	5.00°-3	26
pH		7.575	0.127	0.000	8.3 -2	7.2 -2	26
NO_3-N	mg/1	2.86	0.1275	0.0329	3.04 -1	2.64 -1	15
PO_4-P	mg/1	0.087	0.0272	0.0071	0.128 -1	0.044-1	14
NH_3-N	mg/1	0.089	0.0414	0.0130	0.162 -1	0.029-1	10
SO_4	mg/1	18.3	0.6465	0.2891	19.0 -1	17.4 -1	5
SiO_2	mg/1	13.9	1.689	0.4516	15.5 -1	9.1 -1	14
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	48.7	3.537	0.9452	56.4 -1	44.0 -1	14
Cl	mg/1	18.5	5.707	3.295	24.0 -1	12.6 -1	3
Ca Hard.	mg/1	52.1	3.202	1.849	55.4 -1	49.0 -1	3
Tot. Hard.	mg/1	84.8	3.666	2.117	88.0 -1	80.8 -1	3
Se	mg/1	10.4	6.334	0.1350	11.6 -1	9.5 -1	22
Zn	mg/1	1.8	0.3889	0.2749	2.05 -1	1.5 -1	2
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	.086	0.0259	0.0055	0.144 -1	0.052-2	21
Fe	mg/1	.25	0.1647	0.0377	0,69 -1	0.11 -1	19
Na	mg/1	5.9	0.9004	0.2847	7.4 -1	4.7 -1	10
K	mg/1	3.0	0.5028	0.1676	4.3 -1	2.6 -1	9
Daylength		9'50"			10'12"	9'31"	

Table 81. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 6 10.3 mg/1 Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	7.83°	3.00°	0.14°	11.11° -2	3.33° -1	26
pH		7.771	0.273	0.010	8.7 -1	7.3 -47	26
NO_3-N	mg/1	2.87	0.1462	0.0377	3.14 -1	2.63 -1	15
PO_4-P	mg/1	0.097	0.0356	0.0095	0.158 -1	0.044 -1	14
NH_3-N	mg/1	0.109	0.0693	0.0219	0.260 -1	<0.02 -1	10
SO_4	mg/1	18.5	0.5495	2.458	19.3 -1	17.9 -1	5
SiO_2	mg/1	13.6	2.008	0.5366	15.5 -2	7.6 -1	14
Alk-P	mg/1	—	—	—	—	—	—
Alk-MO	mg/1	47.4	4.281	1.144	54.6 -1	39.2 -1	14
Cl	mg/1	11.5	1.286	0.7424	12.4 -1	10.0 -1	3
Ca Hard.	mg/1	48.0	1.969	1.137	49.6 -1	45.8 -1	3
Tot. Hard.	mg/1	80.9	4.636	2.677	84.0 -1	75.6 -1	3
Se	mg/1	10.3	0.4938	0.1053	11.3 -1	9.3 -1	22
Zn	mg/1	2.1	0.7071	0.5000	2.6 -1	1.6 -1	2
Cu	mg/1	—	—	—	—	—	—
Mn	mg/1	0.106	0.0405	0.0084	0.255 -1	0.071 -1	21
Fe	mg/1	.30	0.1873	0.0429	0.79 -1	0.14 -1	19
Na	mg/1	5.7	0.6903	0.2183	6.7 -1	5.0 -3	10
K	mg/1	3.0	0.4609	0.1537	4.1 -1	2.5 -1	9
Daylength		9'50"			10'12"	9'31"	

Table 82. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 3 1.0 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	8.17°	3.427°	0.148°	12.22°	-4	5.00°	-3	26
pH		7.442	0.136	0.000	8.3	-2	7.3	-150	26
NO_3-N	mg/l	2.80	0.1687	0.0435	3.12	-1	2.51	-1	15
PO_4-P	mg/l	0.07	0.0363	0.0095	0.142	-1	0.036	-1	14
NH_3-N	mg/l	0.101	0.0465	0.0145	0.172	-1	0.020	-1	10
SO_4	mg/l	18.4	0.5612	0.2589	19.0	-1	17.5	-1	5
SiO_2	mg/l	13.5	1.612	0.4309	15.5	-1	10.0	-1	14
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	54.7	4.860	1.299	66.6	-1	49.2	-1	14
Cl	mg/l	9.3	0.3055	0.1764	9.6	-1	9.0	-1	3
Ca Hard.	mg/l	52.3	8.386	4.842	62.0	-1	47.0	-1	3
Tot. Hard.	mg/l	83.2	5.303	3.062	88.4	-1	77.8	-1	3
Se	mg/l	1.07	0.1015	0.0214	1.35	-1	0.90	-1	22
Zn	mg/l	2.8	1.273	0.9000	3.7	-1	1.9	-1	2
Cu	mg/l	—	—	—	—		—		—
Mn	mg/l	0.087	0.0289	0.0063	0.153	-1	0.051	-2	21
Fe	mg/l	0.25	0.2203	0.0505	0.87	-1	0.07	-1	19
Na	mg/l	5.7	0.8478	0.2681	7.7	-1	4.8	-1	10
K	mg/l	3.0	0.5431	0.1810	4.3	-1	2.5	-1	9
Daylength		9'50"			10'12"		9'31"		

Table 83. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 7 1.0 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	7.94°	2.99°	0.14°	11.11° -3	3.89° -1	26
pH		7.591	0.326	0.010	8.7 -1	6.9 -5	26
NO_3-N	mg/l	2.85	0.1699	0.0438	3.17 -1	2.55 -1	15
PO_4-P	mg/l	0.081	0.0358	0.0095	0.139 -1	0.038 -1	14
NH_3-N	mg/l	0.078	0.0503	0.0158	0.168 -1	$\leq$0.02 -1	10
SO_4	mg/l	18.5	0.8689	0.3886	19.6 -1	17.6 -1	5
SiO_2	mg/l	12.7	2.644	0.7067	15.3 -1	5.4 -1	14
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	52.8	2.733	0.7305	58.8 -1	49.4 -2	14
Cl	mg/l	10.0	0.2000	0.1155	10.2 -1	9.8 -1	3
Ca Hard.	mg/l	47.0	2.307	1.332	49.6 -1	45.2 -1	3
Tot. Hard.	mg/l	77.9	1.405	0.8110	79.2 -1	76.4 -1	3
Se	mg/l	1.04	0.1242	0.0265	1.35 -1	0.80 -1	22
Zn	mg/l	1.9	0.4949	0.3500	2.2 -1	1.5 -1	2
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.084	0.0266	0.0055	0.165 -1	0.051 -1	21
Fe	mg/l	0.25	0.1869	0.0429	0.75 -1	0.10 -1	19
Na	mg/l	5.6	0.7355	0.2326	6.7 -1	4.5 -1	10
K	mg/l	0.25	0.1869	0.0429	0.75 -1	0.10 -1	19
Daylength		9'50"			10'12"	9'31"	

Table 84. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 4 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	8.17°	3.427°	0.148°	12.22° -4	5.00° -3	26
pH		7.521	0.261	0.010	8.2 -2	7.0 -8	26
NO_3-N	mg/l	2.81	0.1134	0.0292	2.94 -1	2.59 -1	15
PO_4-P	mg/l	0.081	0.0333	0.0084	0.134 -1	0.037 -2	14
NH_3-N	mg/l	0.073	0.0516	0.0161	0.140 -1	<0.02 -2	10
SO_4	mg/l	17.8	0.8643	0.3865	19.0 -1	16.6 -1	5
SiO_2	mg/l	13.6	2.147	0.5739	16.1 -1	7.9 -1	14
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	54.8	4.790	1.280	61.6 -1	44.0 -1	14
Cl	mg/l	10.9	1.677	0.8386	13.4 -1	9.8 -1	4
Ca Hard.	mg/l	52.1	4.001	2.310	56.0 -1	48.0 -1	3
Tot. Hard.	mg/l	82.7	0.9018	0.5207	83.6 -1	81.8 -1	3
Se	mg/l	<0.1	---	---	<0.1 -	<0.1 -	22
Zn	mg/l	3.1	2.051	1.450	4.5 -1	1.6 -1	2
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.080	0.0346	0.0071	0.182 -1	0.025 -1	22
Fe	mg/l	0.23	0.1495	0.0342	0.67 -1	0.12 -1	19
Na	mg/l	5.9	0.9095	0.2876	7.5 -1	5.0 -3	10
K	mg/l	2.9	0.1856	0.0618	3.1 -3	2.6 -1	9
Daylength		9:50"			10'12"	9'31"	

Table 85. SUMMARY CHART - SELENIUM 11-9-72/12-4-72
Test 8 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	8.05°	2.99°	0.14°	11.67° -1	3.89° -1	26
pH		7.683	0.221	0.000	8.8 -1	7.0 -3	26
NO_3-N	mg/l	2.79	0.1311	0.0338	3.09 -1	2.59 -1	15
PO_4-P	mg/l	0.078	0.0356	0.0095	0.132 -1	0.026 -1	14
NH_3-N	mg/l	0.079	0.0453	0.0141	0.148 -1	<0.02 -1	10
SO_4	mg/l	18.6	1.007	0.4506	20.4 -1	18.1 -2	5
SiO_2	mg/l	13.6	2.308	0.6167	16.0 -2	7.0 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	53.3	1.725	0.4609	55.8 -1	50.0 -1	14
Cl	mg/l	11.3	1.509	0.7549	13.4 -1	10.2 -1	4
Ca Hard.	mg/l	47.1	3.828	2.210	51.4 -1	44.0 -1	3
Tot. Hard.	mg/l	77.4	3.516	2.029	80.0 -1	73.4 -1	3
Se	mg/l	<0.1	--	--	<0.1 -	<0.1 -	22
Zn	mg/l	2.7	1.697	1.200	3.9 -1	1.5 -1	2
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.085	0.0259	0.0055	0.138 -1	0.038 -1	21
Fe	mg/l	0.22	0.1326	0.0303	0.56 -1	0.11 -1	19
Na	mg/l	5.7	0.7340	0.2321	7.2 -1	5.0 -1	10
K	mg/l	0.22	0.1326	0.0303	0.56 -1	0.11 -1	19
Daylength		9'50"			10'21"	9'31"	

Table 86. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 1 41.5 mg/l Selenate

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH		7.218	0.356	0.010	7.9 -15	5.7 -2	39
NO_3-N	mg/l	2.88	0.2349	0.0460	3.25 -1	2.35 -1	26
PO_4-P	mg/l	0.129	0.0305	0.0055	0.183 -1	0.056 -1	22
NH_3-N	mg/l	0.058	0.0318	0.0077	0.102 -1	<0.02 -2	15
SO_4	mg/l	27.3	4.193	1.210	37.4 -1	23.8 -1	12
SiO_2	mg/l	12.0	0.7447	0.1460	13.4 -2	10.4 -1	26
Alk-P	mg/l	--	--	--	—	—	--
Alk-MO	mg/l	18.8	15.12	2.966	48.0 -1	6.0 -5	26
Cl	mg/l	22.7	11.17	3.368	32.0 -1	5.0 -2	11
Ca Hard.	mg/l	49.7	4.692	1.415	58.0 -1	44.0 -1	11
Tot. Hard.	mg/l	83.0	4.535	1.367	94.0 -1	77.0 -1	11
Se	mg/l	41.5	5.753	0.9333	67.0 -1	34.5 -1	38
Zn	mg/l	0.016	--	--	0.017 -1	0.015 -1	3
Cu	mg/l	--	--	--	—	--	--
Mn	mg/l	0.097	0.0214	0.0032	0.144 -1	0.080 -1	30
Fe	mg/l	0.16	0.0669	0.0126	0.35 -1	0.09 -2	27
Na	mg/l	15.3	12.12	3.030	33.3 -1	4.8 -1	16
K	mg/l	2.0	0.1143	0.0316	2.2 -1	1.8 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 87. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 5 40.5 mg/1 Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH		7.271	0.277	0.000	7.9 -3	6.2 -4	39
NO_3-N	mg/1	2.98	0.1908	0.0366	3.25 -2	2.69 -1	27
PO_4-P	mg/1	0.059	0.0100	--	0.092 -1	0.041 -1	27
NH_3-N	mg/1	0.052	0.0632	0.0158	0.189 -1	<0.02 -7	16
SO_4	mg/1	20.2	1.541	0.4448	23.4 -1	17.7 -1	12
SiO_2	mg/1	11.9	0.8930	0.1718	13.4 -1	9.9 -1	27
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	27.5	10.16	1.955	70.0 -1	19.8 -1	27
Cl	mg/1	37.9	12.50	3.769	46.0 -1	4.0 -1	11
Ca Hard.	mg/1	49.8	7.784	2.247	66.0 -1	33.6 -1	12
Tot. Hard.	mg/1	80.1	2.166	0.6530	84.0 -1	77.0 -1	11
Se	mg/1	40.5	5.718	0.9399	66.0 -1	28.0 -1	37
Zn	mg/1	0.007	--	--	0.008 -1	0.006 -1	3
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	0.066	0.0138	--	0.097 -1	0.044 -1	30
Fe	mg/1	0.18	0.1124	0.0214	0.48 -1	0.09 -3	27
Na	mg/1	6.3	2.718	0.6794	13,5 -1	4.2 -1	16
K	mg/1	2.1	0.2315	0.0642	2.4 -2	1.7 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 88. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 2 10.6 mg/l Selenate

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH	mg/l	7.594	0.313	0.010	8.5 -2	6.6 -1	39
NO_3-N	mg/l	2.91	0.2025	0.0396	3.25 -1	2.46 -1	26
PO_4-P	mg/l	0.099	0.0309	0.0055	0.156 -1	0.038 -1	26
NH_3-N	mg/l	0.049	0.0358	0.0089	0.104 -1	<0.02 -4	15
SO_4	mg/l	21.6	1.457	0.4205	24.4 -1	20.0 -1	12
SiO_2	mg/l	12.3	0.6630	0.1300	13.7 -1	11.4 -2	26
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	40.2	2.993	0.5869	47.0 -1	36.03	26
Cl	mg/l	13.3	6.979	2.104	32.0 -1	6.0 -1	11
Ca Hard.	mg/l	51.5	3.830	1.155	58.0 -1	44.0 -1	11
Tot. Hard.	mg/l	82.2	3.488	1.052	87.0 -1	76.0 -1	11
Se	mg/l	10.6	2.185	0.3592	22.0 -1	8.2 -1	37
Zn	mg/l	0.006	0.0031	--	0.007 -1	0.005 -1	3
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.059	0.0179	0.0032	0.100 -1	0.033 -1	30
Fe	mg/l	0.16	0.0782	0.0148	0.38 -1	0.08 -2	27
Na	mg/l	6.8	2.257	0.5641	11.2 -1	4.8 -1	16
K	mg/l	2.1	0.2022	0.0560	2.5 -1	1.7 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 89. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 6 10.4 mg/1 Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH		7.554	0.306	0.010	8.6 -3	6.9 -1	39
NO_3-N	mg/1	2.69	0.2647	0.0519	3.19 -1	2.09 -1	26
PO_4-P	mg/1	0.058	0.0286	0.0055	0.110 -1	0.023 -1	26
NH_3-N	mg/1	0.045	0.0370	0.0095	0.124 -1	<0.02 -4	15
SO_4	mg/1	19.7	0.8332	0.2512	21.0 -1	18.4 -1	11
SiO_2	mg/1	11.7	1.168	2.336	13.3 -1	9.0 -1	25
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	44.2	4.636	0.9093	56.0 -1	36.0 -1	26
Cl	mg/1	16.0	4.175	1.259	23.0 -1	7.0 -1	11
Ca Hard.	mg/1	50.0	4.147	1.250	58.0 -1	43.0 -	11
Tot. Hard.	mg/1	80.5	3.251	0.9803	86.0 -2	76.0 -1	11
Se	mg/1	10.4	1.824	0.2959	16.0 -1	7.6 -1	38
Zn	mg/1	0.006	--	--	0.008 -1	0.004 -1	3
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	0.069	0.0202	0.0032	0.118 -1	0.022 -1	30
Fe	mg/1	--	--	--	0.45 -1	0.06 -2	27
Na	mg/1	5.4	0.8430	0.2107	7.2 -1	4.2 -1	16
K	mg/1	2.0	0.1894	0.0525	2.4 -1	1.7 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 90. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 3 1.2 mg/1 Selenate

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH		7.901	0.500	0.014	8.9 -3	7.1 -10	39
NO_3-N	mg/1	2.33	0.3671	0.0719	2.88 -1	1.81 -2	26
PO_4-P	mg/1	0.077	0.0409	0.0077	0.168 -1	0.014 -1	26
NH_3-N	mg/1	0.056	0.0418	0.0105	0.174 -1	<0.020 -1	15
SO_4	mg/1	19.4	1.090	0.3286	21.3 -1	17.6 -1	11
SiO_2	mg/1	11.9	0.7851	0.1539	13.6 -1	9.8 -1	26
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	48.8	3.088	0.6055	56.0 -1	44.0 -2	26
Cl	mg/1	8.2	0.9749	0.2939	9.6 -2	6.4 -1	11
Ca Hard.	mg/1	49.7	3.859	1.163	56.0 -1	43.6 -1	11
Tot. Hard.	mg/1	81.6	3.955	1.193	89.0 -1	72.0 -1	11
Se	mg/1	1.2	0.2115	0.0352	2.0 -1	0.8 -1	36
Zn	mg/1	0.007	--	--	0.008 -1	0.006 -1	3
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	0.055	0.0257	0.0045	0.128 -1	0.020 -1	30
Fe	mg/1	0.16	0.1174	0.0226	0.57 -1	0.03 -1	27
Na	mg/1	5.3	1.174	0.2934	9.4 -1	4.2 -2	16
K	mg/1	2.2	0.1898	0.0526	2.5 -2	1.9 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 91. SUMMARY CHART - .SELENIUM 4-3-73/5-11-73
Test 7 1.1 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.0° -1	5.56° -4	751
pH		7.616	0.424	0.014	8.7 -2	6.5 -1	39
NO_3-N	mg/l	2.07	0.5017	0.0984	2.80 -1	1.46 -1	26
PO_4-P	mg/l	0.067	0.0451	0.0084	0.160 -1	0.008 -1	26
NH_3-N	mg/l	0.058	0.0421	0.0105	0.154 -1	<0.02 -2	15
SO_4	mg/l	19.6	0.6360	0.1918	20.4 -1	18.4 -1	11
SiO_2	mg/l	10.2	1.468	0.2879	12.8 -1	7.0 -1	26
Alk-P	mg/l	0.65	1.938	0.3800	8.0 -1	0.0 -23	26
Alk-MO	mg/l	50.7	5.577	1.097	62.0 -1	42.0 -1	26
Cl	mg/l	7.7	1.398	0.4216	10.0 -1	5.6 -1	11
Ca Hard.	mg/l	48.2	2.757	0.8312	54.0 -1	44.2 -1	11
Tot. Hard.	mg/l	80.4	3.641	1.098	84.0 -3	74.0 -1	11
Se	mg/l	1.1	0.1978	0.0329	1.8 -1	0.8 -2	36
Zn	mg/l	0.007	0.0032	--	0.007 -2	0.006 -1	3
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.062	0.0187	0.0032	0.100 -1	0.021 -1	30
Fe	mg/l	0.15	0.0932	0.0179	0.41 -1	0.05 -1	27
Na	mg/l	5.1	0.7646	0.1912	7.5 -1	4.0 -1	16
K	mg/l	2.1	0.2221	0.0616	2.5 -1	1.7 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 92. SUMMARY CHART - SELENIUM 4-3-73/5-11-73
Test 8 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	11.79°	4.893°	0.178°	20.00° -1	5.56° -4	751
pH		7.900	0.503	0.017	8.7 -2	6.5 -2	39
NO_3-N	mg/l	1.61	0.5356	0.1050	2.64 -1	0.90 -1	26
PO_4-P	mg/l	0.102	0.0536	0.0105	0.200 -1	0.021 -1	26
NH_3-N	mg/l	0.067	0.0401	0.0100	0.170 -1	<0.02 -2	15
SO_4	mg/l	19.6	0.4945	0.1491	20.3 -1	18.8 -1	11
SiO_2	mg/l	6.3	3.194	0.6263	12.0 -1	2.0 -1	26
Alk-P	mg/l	3.0	5.302	1.039	16.0 -1	0.0 -17	26
Alk-MO	mg/l	55.6	11.88	2.331	78.0 -1	23.0 -1	26
Cl	mg/l	7.9	1.327	0.4002	9.6 -1	5.2 -1	11
Ca Hard.	mg/l	49.2	4.763	1.436	60.0 -1	43.4 -1	11
Tot. Hard.	mg/l	80.2	3.371	1.016	85.0 -1	74.0 -1	11
Se	mg/l	<0.3	--	--	<0.3 -	<0.3 -	36
Zn	mg/l	0.011	--	--	0.012 -1	0.010 -1	3
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.078	0.0217	0.0032	0.118 -1	0.037 -2	30
Fe	mg/l	0.16	0.0569	0.0109	0.32 -1	0.09 -1	27
Na	mg/l	6.3	2.306	0.5764	10.4 -1	4.2 -2	16
K	mg/l	2.0	0.2035	0.0564	2.5 -1	1.8 -1	13
Daylength		13'31"			14'15"	12'44"	39

Table 93. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 5 40.9 mg/l Selenite

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.10°	4.233°	0.2108°	23.33°	-2	16.11°	-12	19
pH		7.701	0.446	0.020	8.6	-2	6.4	- 1	19
NO_3-N	mg/l	3.00	0.289	0.091	3.32	-1	2.61	- 1	10
PO_4-P	mg/l	0.049	---	---	0.071	-1	0.036	- 1	12
NH_3-N	mg/l	0.080	0.014	---	0.10	-1	0.064	- 1	5
SO_4	mg/l	17.8	0.212	0.150	17.9	-1	17.6		2
SiO_2	mg/l	14.1	1.095	0.346	15.6	-1	12.0	- 1	10
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	29.0	1.414	0.447	32.0	-1	28.0	- 6	10
Cl	mg/l	11.4	0.495	0.350	11.7	-1	11.0	- 1	2
Ca Hard.	mg/l	51.0	1.414	1.00	52.0	-1	50.0	- 1	2
Tot. Hard.	mg/l	81.0	1.414	1.00	82.0	-1	80.0	- 1	2
Se	mg/l	40.9	1.89	0.479	44.0	-1	38.0	- 1	16
Zn	mg/l	0.012	---	---	0.012	-1	0.012	- 1	1
Cu	mg/l	---	---	---	---		---		---
Mn	mg/l	0.094	0.024	---	0.128	-1	0.024	- 1	12
Fe	mg/l	0.159	0.037	0.010	0.230	-1	0.11	- 2	12
Na	mg/l	5.6	0.320	0.113	6.0	-1	4.9	- 1	8
K	mg/l	2.0	0.121	0.046	2.2	-1	1.8	- 1	7
Daylength		14'58"			14'59"		14'56"		

Table 94. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 1 40.4 mg/l Selenate

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.10°	4.233°	0.2108°	23.33°	-1	16.11°	- 4	19
pH		8.071	0.557	0.026	8.7	-1	6.4	- 3	19
NO_3-N	mg/l	2.91	0.063	0.020	3.01	-1	2.82	- 1	10
PO_4-P	mg/l	0.076	0.0374	0.0100	0.130	-1	0.016	- 2	11
NH_3-N	mg/l	0.067	0.0316	0.0141	0.103	-1	0.029	- 1	5
SO_4	mg/l	29.4	--	--	29.4	-	29.4	-	2
SiO_2	mg/l	14.97	0.490	0.155	15.9	-1	14.2	- 1	10
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	48.8	6.877	2.174	58.0	-1	34.0	- 1	10
Cl	mg/l	9.8	0.283	0.200	10.0	-1	9.6	- 1	2
Ca Hard.	mg/l	50.0	--	--	50.0	-	50.0	-	2
Tot. Hard.	mg/l	84.0	--	--	84.0	-	84.0	-	2
Se	mg/l	40.4	2.830	.708	47.0	-1	37.0	- 1	16
Zn	mg/l	0.012	--	--	0.012	-	0.012	-	1
Cu	mg/l	--	--	--	--		--		--
Mn	mg/l	0.076	0.049	0.013	0.172	-1	0.020	- 1	14
Fe	mg/l	0.184	0.147	0.039	0.58	-1	0.08	- 1	14
Na	mg/l	25.1	4.78	1.69	30.0	-1	15.5	- 1	8
K	mg/l	2.1	0.115	0.044	2.2	-3	1.9	- 1	7
Daylength		14'58"			14'59"		14'56"		

Table 95. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 6 10.6 mg/l Selenite

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.10°	4.233°	.2108°	23.33°	-2	16.11°	-12	19
pH		7.754	0.403	0.017	8.5	-2	6.5	- 1	19
NO_3-N	mg/l	2.70	0.351	0.111	3.03	-1	2.10	- 1	10
PO_4-P	mg/l	0.028	—	—	0.041	-1	0.016	- 1	12
NH_3-N	mg/l	0.075	0.030	0.010	0.110	-1	0.043	- 1	5
SO_4	mg/l	18.0	0.99	0.70	18.7		17.3		2
SiO_2	mg/l	13.3	2.089	0.661	16.8	-1	10.2	- 1	10
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	47.8	2.573	0.814	52.0	-2	44.0	- 1	10
Cl	mg/l	10.9	0.707	0.500	11.4	-1	10.4	- 1	2
Ca Hard.	mg/l	52.0	--	--	52.0	-1	52.0	- 1	2
Tot. Hard.	mg/l	84.0	2.828	2.000	86.0	-1	82.0	- 1	2
Se	mg/l	10.6	1.071	0.268	12.8	-1	9.2	- 2	16
Zn	mg/l	0.009	--	--	0.009	-	0.009	-	1
Cu	mg/l	--	--	--	--		--		--
Mn	mg/l	0.095	0.07	0.017	0.256	-1	0.020	- 1	14
Fe	mg/l	0.16	0.079	0.020	0.41	-1	0.10	- 1	13
Na	mg/l	5.6	0.45	0.16	6.3	-1	4.9	- 1	8
K	mg/l	2.0	1.21	0.046	2.2	-1	1.8	- 1	7
Daylength		14'58"			14'59"		14'56"		

Table 96. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 2 10.3 mg/1 Selenate

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.10°	4.233°	0.2108°	23.33°	-2	16.11°	-12	19
pH		8.151	0.567	0.024	8.9	-3	6.4	- 1	19
NO_3-N	mg/1	2.89	0.082	0.024	3.01	-1	2.75	- 1	10
PO_4-P	mg/1	0.078	0.0316	—	0.113	-1	0.022	- 1	12
NH_3-N	mg/1	0.051	0.0331	0.0141	0.09	-1	<0.02	- 1	5
SO_4	mg/1	21.0	0.566	0.40	21.4	-1	20.6	- 1	2
SiO_2	mg/1	15.3	0.721	0.228	16.4	-1	14.4	- 1	10
Alk-P	mg/1	—	—	—	—		—		—
Alk-MO	mg/1	52.0	6.324	2.000	68.0	-1	44.0	- 1	10
Cl	mg/1	10.6	0.283	0.200	10.8	-1	10.4	- 1	2
Ca Hard.	mg/1	50.0	—	—	50.0	-	50.0	-	2
Tot. Hard.	mg/1	84.0	—	—	84.0	-	84.0	-	2
Se	mg/1	10.3	0.516	0.129	10.8	-2	9.0	- 1	16
Zn	mg/1	0.008	—	—	0.008	-	0.008	-	1
Cu	mg/1	—	—	—	—		—		—
Mn	mg/1	0.102	0.082	0.022	0.290	-1	0.014	- 1	14
Fe	mg/1	0.169	0.118	0.031	0.49	-1	0.08	- 1	14
Na	mg/1	9.4	2.130	0.753	11.6	-1	5.8	- 1	8
K	mg/1	2.114	.168	—	2.3	-2	1.8	- 1	7
Daylength		14'58"			14'59"		14'56"		

Table 97. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 3 1.1 mg/l Selenate

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.10°	4.233°	0.2108°	23.33°	-2	16.11°	-12	19
pH		7.867	0.433	0.010	8.6	-1	6.4	- 3	19
NO_3-N	mg/l	2.76	0.229	0.072	3.00	-1	2.33	- 1	10
PO_4-P	mg/l	0.063	0.0300	---	0.122	-1	0.011	- 1	12
NH_3-N	mg/l	0.060	0.0400	0.0173	0.100	-1	<0.02	- 1	5
SO_4	mg/l	19.0	0.566	0.400	19.4	-1	18.6	- 1	2
SiO_2	mg/l	15.3	0.482	0.152	16.0	-2	14.8	- 2	10
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	51.0	6.880	2.176	56.0	-1	32.0	- 1	10
Cl	mg/l	9.4	0.283	0.200	9.6	-1	9.2	- 1	2
Ca Hard.	mg/l	51.0	4.243	3.00	54.0	-1	48.0	- 1	2
Tot. Hard.	mg/l	85.0	4.243	3.00	88.0	-1	82.0	- 1	2
Se	mg/l	1.17	0.153	0.038	1.3	-3	0.8	- 1	16
Zn	mg/l	0.013	---	---	0.013	-	0.013	-	1
Cu	mg/l	---	---	---	---		---		---
Mn	mg/l	0.093	0.071	0.019	0.245	-1	0.022	- 1	14
Fe	mg/l	0.148	0.090	0.024	0.41	-1	0.08	- 2	14
Na	mg/l	5.85	0.51	0.18	6.6	-1	5.1	- 1	8
K	mg/l	2.06	0.140	0.052	2.2	-2	1.8	- 1	7
Daylength		14'58"			14'59"		14'56"		

Table 98. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 7 1.1 mg/l Selenate

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.10°	4.233°	0.2108°	23.33° -2	16.11° -12	19
pH		8.14	0.5224	0.0244	8.9 -2	6.2 -1	19
NO_3-N	mg/l	2.33	0.508	0.160	2.90 -1	1.63 -1	10
PO_4-P	mg/l	0.036	0.020	—	0.061 -1	0.002 -1	12
NH_3-N	mg/l	0.079	0.030	0.010	0.123 -1	0.046 -1	5
SO_4	mg/l	18.3	0.566	0.40	18.7 -1	17.9 -1	2
SiO_2	mg/l	11.7	2.512	0.79	14.6 -1	8.0 -1	10
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	53.4	2.119	0.670	58.0 -1	50.0 -1	10
Cl	mg/l	8.2	0.283	0.209	8.4 -1	8.0 -1	2
Ca Hard.	mg/l	52.0	—	—	52.0 -1	52.0 -1	2
Tot. Hard.	mg/l	86.0	5.657	4.00	90.0 -1	82.0 -1	2
Se	mg/l	1.08	0.160	0.0400	1.4 -1	0.8 -1	16
Zn	mg/l	0.009	—	—	0.009 -	0.009 -	1
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.074	0.068	0.017	0.232 -1	0.014 -1	14
Fe	mg/l	0.13	0.065	0.017	0.32 -1	0.06 -1	14
Na	mg/l	5.6	0.269	0.095	6.0 -1	5.2 -1	8
K	mg/l	2.0	0.129	0.048	2.2 -1	1.8 -1	7
Daylength		14'58"			14'59"	14'56"	

Table 99. SUMMARY CHART - SELENIUM 6-15-73/7-3-73
Test 8 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.10°	4.233°	0.2108°	23.33° -2	16.11° -12	19
pH		7.88	0 .5263	0.0244	8.7 -4	6.2 -1	19
NO_3-N	mg/l	2.29	0 .564	0.178	3.00 -1	1.49 -1	10
PO_4-P	mg/l	0.038	0 .0100	--	0.056 -1	0.011 -1	12
NH_3-N	mg/l	0.099	0 .0806	0.0360	0.21 -1	<0.02 -1	5
SO_4	mg/l	18.8	0 .636	0.450	19.2 -1	18.3 -1	2
SiO_2	mg/l	10.4	3.310	1.046	14.1 -1	5.5 -1	10
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	54.4	2.458	0.777	60.0 -1	52.0 -3	10
Cl	mg/l	9.6	0.566	0.400	10.0 -1	9.2 -1	2
Ca Hard.	mg/l	53.0	1.414	1.000	54.0 -1	52.0 -1	2
Tot. Hard.	mg/l	83.0	1.414	1.000	84.0 -1	82.0 -1	2
Se	mg/l	<0.3	--	--	<0.3 -	<0.3 -	16
Zn	mg/l	0.008	--	--	0.008 -	0.008 -	1
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.060	0 .045	0.010	0.14 -1	0.012 -1	14
Fe	mg/l	0.112	0 .030	--	0.19 -1	0.07 -1	14
Na	mg/l	5.5	0 .214	0.075	5.8 -1	5.2 -1	8
K	mg/l	2.0	0 .121	0.046	2.2 -1	1.8 -1	7
Daylength		14'58"			14'59"	14'56"	

Table 100. SUMMARY CHART - BORON 5-20-70/6-13-70
Test 1 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	--	--	--	--	--	
pH		--	--	--	--	--	
NO_3-N	mg/l	2.02	0.3638	0.0939	2.80 -1	1.51 -1	15
PO_4-P	mg/l	0.018	0.0141	0.0029	0.052 -2	0.001 -2	23
NH_3-N	mg/l	0.050	0.010	0.0037	0.068 -1	0.038 -2	7
SO_4	mg/l	14.9	1.10	0.635	16.0 -1	13.8 -1	3
SiO_2	mg/l	12.1	3.254	0.6936	19.2 -1	6.98 -1	22
Alk-P	mg/l	9.66	3.785	2.185	14.0 -1	7.0 -1	3
Alk-MO	mg/l	65.3	11.29	3.99	88.0 -1	53.0 -1	8
Cl	mg/l	12.0	2.82	2.00	14.0 -1	10.0 -1	2
Ca Hard.	mg/l	54.0	--	--	59.0 -1	49.0 -1	2
Tot. Hard.	mg/l	93.1	--	--	94.0 -1	92.2 -1	2
B	mg/l	0.03	0.0097	0.0022	0.05 -2	0.02 -5	19
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.029	0.0117	0.0026	0.056 -1	0.008 -1	19
Fe	mg/l	0.25	0.1501	0.0336	0.82 -1	0.09 -1	20
Na	mg/l	9.0	2.423	0.9153	12.4 -1	6.0 -1	7
K	mg/l	4.9	0.9263	0.3501	5.9 -2	3.4 -1	7
Daylength		14'46"			14'58"	14'03"	

Table 101. SUMMARY CHART - BORON 5-20-70/6-13-70
Test 2 0.15 mg/l

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	--	--	--	--	--	--
pH		--	--	--	--	--	--
NO_3-N	mg/l	1.82	0.4290	0.1147	2.28 -1	1.03 -1	14
PO_4-P	mg/l	0.015	0.0124	0.0024	0.045 -1	0.001 -1	23
NH_3-N	mg/l	0.048	0.0084	0.0032	0.061 -1	0.034 -1	7
SO_4	mg/l	15.0	1.301	0.7513	16.3 -1	13.7 -1	3
SiO_2	mg/l	10.9	2.476	0.5279	14.5 -1	5.8 -1	22
Alk-P	mg/l	5.5	1.33	0.76	7.7 -1	4.0 -1	3
Alk-MO	mg/l	64.9	7.61	2.69	72.0 -2	52.4 -1	8
Cl	mg/l	12.1	2.68	1.90	14.0 -1	10.2 -1	2
Ca Hard.	mg/l	51.7	1.83	1.29	53.0 -1	50.4 -1	2
Tot. Hard.	mg/l	81.0	--	--	94.0 -1	68.0 -1	2
B	mg/l	0.15	0.0387	0.0084	0.28 -1	0.10 -1	19
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.031	0.0157	0.0036	0.055 -1	0.006 -1	19
Fe	mg/l	0.21	0.0574	0.0128	0.29 -2	0.12 -2	20
Na	mg/l	9.1	2.064	0.7800	11.5 -1	6.2 -1	7
K	mg/l	5.4	1.471	0.5563	7.7 -1	3.4 -1	7
Daylength		14'46"			14'58"	14'03"	

Table 102. SUMMARY CHART - BORON 5-20-70/6-13-70
Test 3 0.52 mg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	--	--	--	--	--	--
pH		--	--	--	--	--	--
NO_3-N	mg/l	1.93	0.2705	0.0698	2.38 -1	1.52 -1	15
PO_4-P	mg/l	0.018	0.0184	0.0032	0.064 -1	0.001 -1	22
NH_3-N	mg/l	0.050	0.0109	0.0032	0.073 -1	0.037 -1	7
SO_4	mg/l	15.5	0.8145	0.4702	16.1 -1	14.6 -1	3
SiO_2	mg/l	11.2	3.889	0.8292	18.8 -1	5.4 -1	22
Alk-P	mg/l	11.8	4.39	2.19	17.2 -1	6.5 -1	4
Alk-MO	mg/l	66.8	9.11	3.23	82.0 -1	52.2 -1	8
Cl	mg/l	12.3	2.40	1.70	14.0 -1	10.6 -1	2
Ca Hard.	mg/l	57.3	--	--	64.0 -1	50.6 -1	2
Tot. Hard.	mg/l	96.5	--	--	99.0 -1	94.0 -1	2
B	mg/l	0.52	0.0415	0.0095	0.58 -2	0.41 -1	19
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.035	0.0135	0.0030	0.062 -1	0.013 -1	20
Fe	mg/l	0.25	0.0471	0.0105	0.32 -2	0.18 -2	20
Na	mg/l	8.8	1.989	0.7033	11.8 -1	6.0 -1	8
K	mg/l	4.8	2.118	0.7487	9.5 -1	3.1 -2	8
Daylength		14'46"			14'58"	14'03"	

Table 103. SUMMARY CHART - BORON 5-20-70/6-13-70
Test 4 1.07 mg/l

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	--	--	--	--	--	--
pH		--	--	--	--	--	--
NO_3-N	mg/l	1.65	0.3650	0.0942	2.24 -1	0.95 -1	15
PO_4-P	mg/l	0.013	0.0084	0.000	0.031 -1	0.001 -1	22
NH_3-N	mg/l	0.055	0.0134	0.0045	0.072 -1	0.032 -1	7
SO_4	mg/l	15.6	0.7371	0.4256	16.2 -1	14.8 -1	3
SiO_2	mg/l	14.8	4.950	1.055	22.6 -1	6.6 -2	22
Alk-P	mg/l	16.3	--	--	18.6 -1	14.0 -1	2
Alk-MO	mg/l	67.4	14.03	4.960	96.0 -1	52.2 -1	8
Cl	mg/l	10.0	--	--	10.0 -	10.0 -	1
Ca Hard.	mg/l	59.5	--	--	69.0 -1	50.0 -1	2
Tot. Hard.	mg/l	93.0	--	--	98.0 -1	88.0 -1	2
B	mg/l	1.07	0.0547	0.0122	1.19 -1	0.95 -1	19
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.028	0.0154	0.0035	0.052 -1	<0.005 -1	19
Fe	mg/l	0.20	0.0778	0.0174	0.34 -1	0.10 -1	20
Na	mg/l	8.6	2.824	1.067	13.0 -1	6.0 -1	7
K	mg/l	5.1	1.820	0.6879	8.9 -1	3.6 -1	7
Daylength		14'46"			14'58"	14'03"	

Table 104. SUMMARY CHART - BORON 6-26-70/8-6-70
Test 4 1.05 mg/l B

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	23.22°	4.256°	0.8512°	28.66° -1	16.67° -1	25
pH		7.8	0.8542	0.1673	8.8 -3	6.2 -1	26
NO_3-N	mg/l	1.47	0.5805	0.1097	2.76 -1	0.50 -1	28
PO_4-P	mg/l	0.057	0.0363	0.0061	0.147 -1	0.010 -1	35
NH_3-N	mg/l	0.063	0.0218	0.0058	0.104 -1	0.037 -1	14
SO_4	mg/l	17.1	3.868	1.729	23.9 -1	14.5 -1	5
SiO_2	mg/l	14.0	3.748	0.624	22.0 -1	6.1 -1	36
Alk-P	mg/l	--	--	--	00.0	--	16
Alk-MO	mg/l	63.3	7.354	1.839	72.0 -1	48.0 -1	16
Cl	mg/l	15.0	5.899	2.408	24.0 -1	8.0 -1	6
Ca Hard.	mg/l	54.8	8.995	4.976	68.0 -1	48.0 -1	4
Tot. Hard.	mg/l	85.3	4.272	2.136	90.0 -1	80.0 -1	4
Boron	mg/l	1.05	0.0759	0.0134	1.18 -1	0.92 -1	32
Mg	mg/l	6.5	--	--	6.6 -1	6.4 -1	2
Zn	mg/l	0.012	--	--	0.012 -2	0.011 -1	3
Mn	mg/l	0.069	0.0509	0.0079	0.249 -1	0.010 -1	41
Fe	mg/l	0.15	0.0591	0.0098	0.35 -1	0.06 -1	36
Na	mg/l	10.5	1.821	0.6439	13.78 -1	8.2 -1	8
K	mg/l	4.5	0.5354	0.1693	5.25 -1	3.65 -1	10
Daylength		14'44"			15'0"	14'0"	

Table 105. SUMMARY CHART - BORON 6-26-70/8-6-70
Test 3 0.52 mg/l B

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	23.27°	3.509°	0.7017°	26.55° -1	18.83° -1	25
pH		7.6	0.7961	0.1558	8.8 -1	6.1 -1	26
NO_3-N	mg/l	1.66	0.5581	0.1054	2.76 -1	0.68 -1	28
PO_4-P	mg/l	0.057	0.0281	0.0047	0.113 -1	0.010 -1	35
NH_3-N	mg/l	0.061	0.0152	0.0042	0.084 -1	0.035 -1	13
SO_4	mg/l	16.1	2.616	1.068	21.3 -1	14.5 -2	6
SiO_2	mg/l	15.9	2.964	0.494	20.4 -1	8.2 -1	36
Alk-P	mg/l	--	--	--	00.0	--	16
Alk-MO	mg/l	61.6	5.572	1.393	70.0 -1	48.0 -1	16
Cl	mg/l	16.0	4.147	1.693	21.0 -1	12.0 -2	6
Ca Hard.	mg/l	56.5	1.914	0.9574	58.0 -2	54.0 -1	4
Tot. Hard.	mg/l	89.8	6.652	3.326	96.0 -1	84.0 -2	4
Boron	mg/l	0.52	0.0338	0.0057	0.58 -1	0.44 -1	32
Mg	mg/l	6.5	--	--	6.6 -1	6.4 -1	40
Zn	mg/l	0.011	--	--	0.014 -1	0.009 -1	3
Mn	mg/l	0.072	0.0597	0.0094	0.246 -1	0.006 -1	8
Fe	mg/l	0.15	0.0585	0.0097	0.35 -1	0.06 -2	10
Na	mg/l	10.4	1.329	0.4697	12.2 -1	8.1 -1	3
K	mg/l	4.2	0.3755	0.1187	5.0 -1	3.7 -1	2
Daylength		14'44"			15'0"	14'0"	

Table 106. SUMMARY CHART - BORON 6-26-70/8-6-70
Test 2 0.118 mg/l B

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	22.55°	3.325°	0.6649°	27.05°	-1	19.00°	-1	25
pH		7.8	0.7953	0.1558	9.2	-1	7.0	-2	26
NO_3-N	mg/l	1.73	0.499	0.094	2.76	-1	1.08	-2	28
PO_4-P	mg/l	0.078	0.0357	0.0060	0.140	-1	0.013	-1	35
NH_3-N	mg/l	0.059	0.0195	0.0052	0.113	-1	0.035	-1	14
SO_4	mg/l	16.2	1.545	0.691	18.6	-1	14.5	-1	5
SiO_2	mg/l	16.1	3.079	0.513	21.8	-2	9.5	-1	36
Alk-P	mg/l	--	--	--	00.0		--		16
Alk-MO	mg/l	61.4	7.171	1.793	69.0	-1	46.0	-1	16
Cl	mg/l	15.9	5.08	2.075	25.0	-1	12.0	-2	6
Ca Hard.	mg/l	50.0	2.828	1.414	54.0	-1	48.0	-2	4
Tot. Hard.	mg/l	90.8	11.81	5.907	107.0	-1	82.0	-1	4
Boron	mg/l	0.118	0.0128	0.0023	0.15	-1	0.10	-3	32
Mg	mg/l	6.4	--	--	6.4	-1	6.3	-1	2
Zn	mg/l	0.009	--	--	0.010		0.008		3
Mn	mg/l	0.066	0.0438	0.0069	0.186	-1	< 0.005	-1	40
Fe	mg/l	0.18	0.0549	0.0091	0.35	-1	0.06	-1	36
Na	mg/l	9.8	0.9392	0.3321	11.4	-1	8.85	-1	8
K	mg/l	4.3	0.5420	0.1714	5.55	-1	3.6	-1	10
Daylength		14'44"			15'0"		14'0"		

Table 107. SUMMARY CHART - BORON 6-26-70/8-6-70
Test 1 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	22.66°	3.675°	0.7349°	25.66° -1	16.83°-1	25
pH		7.9	0.7495	0.1469	9.4 -1	7.0 -2	26
NO_3-N	mg/l	1.74	0.5189	0.0981	2.76 -2	0.86 -1	28
PO_4-P	mg/l	0.075	0.0381	0.0064	0.156 -1	0.010-1	35
NH_3-N	mg/l	0.059	0.0142	0.0038	0.086 -1	0.040-1	14
SO_4	mg/l	15.5	2.132	0.954	18.6 -1	12.8 -1	5
SiO_2	mg/l	14.7	2.946	0.491	19.9 -1	7.3 -1	36
Alk-P	mg/l	—	—	—	00.0	—	16
Alk-MO	mg/l	59.7	7.576	1.894	68.0 -2	44.0 -1	16
Cl	mg/l	16.8	7.278	2.971	30.0 -1	10.0 -1	6
Ca Hard.	mg/l	50.0	2.828	1.414	54.0 -1	48.0 -2	4
Tot. Hard.	mg/l	99.0	6.218	3.109	108.0 -1	94.0 -1	4
Boron	mg/l	0.029	0.0062	0.0011	0.04 -1	0.02 -6	32
Mg	mg/l	6.6	--	--	6.6 -1	6.6 -1	2
Zn	mg/l	0.01	--	--	0.012 -1	0.007-1	3
Mn	mg/l	0.077	0.077	0.0129	0.520 -1	0.010-1	40
Fe	mg/l	0.22	0.0676	0.0112	0.35 -1	0.09 -1	36
Na	mg/l	10.1	1.311	0.4637	12.1 -1	8.8 -1	8
K	mg/l	4.4	0.4517	0.1428	5.5 -1	3.9 -1	10
Daylength		14'44"			15'0"	14'0"	

Table 108. SUMMARY CHART -BORON 9-24-70/11-4-70
Test 4 1.04 mg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	21.00°	--	--	22.50°	20.00°	3
pH		7.56	--	--	7.8 -1	7.4 -1	3
NO_3-N	mg/l	2.13	0.3003	0.0567	2.98 -1	1.67 -2	28
PO_4-P	mg/l	0.053	0.0100	0.0016	0.082 -1	0.031 -2	35
NH_3-N	mg/l	0.053	0.0173	0.0049	0.086 -1	0.033 -1	12
SO_4	mg/l	15.7	--	--	16.6 -1	14.7 -1	2
SiO_2	mg/l	15.1	1.463	0.251	17.8 -1	12.0 -1	34
Alk-P	mg/l	00.0	--	--	00.0 -	00.0 -	16
Alk-MO	mg/l	48.2	12.81	3.203	61.6 -1	20.0 -1	16
Cl	mg/l	13.3	2.891	1.445	16.0 -1	9.2 -1	4
Ca Hard.	mg/l	49.1	1.774	0.724	51.8 -1	47.0 -1	6
Tot. Hard.	mg/l	95.0	3.162	1.414	98.0 -1	90.0 -1	5
B	mg/l	1.04	0.231	0.397	1.32 -1	0.32 -1	34
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.073	0.1049	0.0172	0.500 -1	<0.02 -1	37
Fe	mg/l	0.16	0.1271	0.0195	0.63 -1	<0.01 -1	42
Na	mg/l	5.9	0.3485	0.1317	6.5 -1	5.5 -2	7
K	mg/l	2.6	0.2422	0.098	3.0 -1	2.3 -1	6
Daylength		11'14"			12'07"	10'24"	

Table 109. SUMMARY CHART - BORON 9-24-70/11-4-70
Test 3 0.488 mg/l

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	20.22°	--	--	21.67°	18.89°	3
pH		7.43	--	--	7.6 -1	7.3 -1	3
NO_3-N	mg/l	2.27	0.1838	0.0347	2.86 -1	2.01 -1	28
PO_4-P	mg/l	0.056	0.0100	0.0016	0.076 -1	0.032 -2	35
NH_3-N	mg/l	0.047	0.0141	0.0044	0.084 -1	0.024 -1	10
SO_4	mg/l	15.5	--	--	16.7 -1	14.2 -1	2
SiO_2	mg/l	15.4	1.391	0.239	19.7 -1	13.2 -1	34
Alk-P	mg/l	4.0	--	--	4.0 -1	4.0 -1	17
Alk-MO	mg/l	49.3	11.73	2.845	62.0 -1	20.0 -1	17
Cl	mg/l	12.5	2.002	1.001	14.0 -2	9.8 -1	4
Ca Hard.	mg/l	49.9	2.818	1.151	54.0 -1	47.0 -1	6
Tot. Hard.	mg/l	95.2	4.381	1.951	98.0 -3	88.0 -1	5
B	mg/l	0.488	0.108	0.018	0.63 -1	0.10 -1	34
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.043	0.0404	0.0070	0.174 -1	<0.01 -2	32
Fe	mg/l	0.170	0.0947	0.0158	0.52 -1	0.03 -1	35
Na	mg/l	5.8	0.3132	0.1184	6.2 -1	5.2 -1	7
K	mg/l	2.6	0.2316	0.0946	3.0 -1	2.4 -2	6
Daylength		11'14"			12'07"	10'24"	

Table 110. SUMMARY CHART - BORON 9-24-70/11-4-70
Test 2 0.125 mg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	21.38°	--	--	22.78° -1	20.00° -1	3
pH		7.53	--	--	7.7 -1	7.4 -1	3
NO_3-N	mg/l	2.28	0.1697	0.0320	2.64 -1	1.99 -1	28
PO_4-P	mg/l	0.055	0.0141	0.0023	0.104 -1	0.028 -1	35
NH_3-N	mg/l	0.043	0.0141	0.0042	0.075 -1	0.020 -1	11
SO_4	mg/l	15.5	--	--	17.6 -1	13.4 -1	2
SiO_2	mg/l	14.9	1.689	0.2895	21.7 -1	12.6 -1	34
Alk-P	mg/l	00.0	--	--	0.0 -	0.0 -	17
Alk-MO	mg/l	48.4	11.69	2.839	63.8 -1	20.0 -1	17
Cl	mg/l	12.5	1.915	0.957	14.0 -2	10.0 -1	4
Ca Hard.	mg/l	51.5	4.877	1.991	58.0 -1	46.0 -1	6
Tot. Hard.	mg/l	96.0	2.000	0.8944	98.0 -2	94.0 -2	5
B	mg/l	0.125	0.0231	0.0039	0.16 -4	0.08 -2	34
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.070	0.0680	0.0122	0.355 -1	<0.02 -1	30
Fe	mg/l	0.20	0.1145	0.0182	0.46 -1	0.030 -1	39
Na	mg/l	5.7	0.2340	0.0884	6.1 -1	5.5 -3	7
K	mg/l	2.4	0.4535	0.1851	2.65 -1	1.5 -1	6
Daylength		11'14"			12'07"	10'24"	

Table 111. SUMMARY CHART - BORON 9-24-70/11-4-70
Test 1 Control 0.032 mg/1

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	21.22°	--	--	22.22° -1	20.00° -1	3
pH		7.96	--	--	8.02	7.9 -1	3
NO_3-N	mg/1	2.18	0.2022	0.0382	2.52 -1	1.76 -1	28
PO_4-P	mg/1	0.053	0.0100	0.0016	0.076 -2	0.028 -1	35
NH_3-N	mg/1	0.047	0.0141	0.0039	0.096 -1	0.031 -1	13
SO_4	mg/1	15.1	--	--	16.0 -1	14.2 -1	2
SiO_2	mg/1	15.1	1.259	0.216	18.6 -1	13.0 -1	34
Alk-P	mg/1	0.0	--	--	0.00 -	0.00 -	17
Alk-MO	mg/1	47.6	11.54	2.80	60.2 -1	24.0 -2	17
Cl	mg/1	13.5	1.000	0.5000	14.0 -3	12.0 -1	4
Ca Hard.	mg/1	49.5	5.205	2.125	59.0 -1	46.0 -3	6
Tot. Hard.	mg/1	94.0	3.162	1.414	98.0 -1	90.0 -1	5
B	mg/1	0.032	0.0086	0.0014	0.05 -2	0.02 -7	36
Zn	mg/1	--	--	--	--	--	--
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	0.067	0.0691	0.0110	0.263 -1	<0.02 -3	39
Fe	mg/1	0.21	0.1433	0.0232	0.77 -1	<0.01 -1	38
Na	mg/1	5.9	0.3162	0.1195	6.2 -2	5.3 -1	7
K	mg/1	2.9	0.5037	0.2056	3.9 -1	2.5 -1	6
Daylength		11'14"			12'07"	10'24"	

Table 112. SUMMARY CHART - BORON 12-15-70/2-9-71
Test 8 2.02 mg/l

Chemical or physical analysis	$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	16.28°	3.512°	0.0974°	22.22°	-1	10.56°	-1	121
pH	7.825	0.281	0.000	9.0	-1	7.2	-1	35
NO_3-N	2.76	0.2224	0.0356	3.36	-1	2.24	-2	39
PO_4-P	0.096	0.03517	0.0053	0.202	-1	0.045	-1	44
NH_3-N	0.036	0.0210	0.0052	0.090	-1	<0.02	-2	16
SO_4	17.6	1.367	0.5584	19.0	-1	15.4	-1	6
SiO_2	12.0	2.188	0.3549	15.9	-1	6.3	-1	38
Alk-P	--	--	--	--		--		--
Alk-MO	49.83	2.95	0.67	55.0	-1	43.0	-1	19
Cl	13.33	2.42	0.99	18.0	-1	12.0	-4	6
Ca Hard.	54.33	2.65	1.08	58.0	-1	50.0	-1	6
Tot. Hard.	85.85	20.97	7.94	104.0	-1	42.0	-1	7
B	2.02	0.3232	0.0563	3.10	-1	1.60	-1	33
Zn	--	--	--	--		--		--
Cu	--	--	--	--		--		--
Mn	0.066	0.0375	0.0057	0.204	-1	0.007	-1	42
Fe	0.15	0.0664	0.0108	0.39	-1	0.06	-1	38
Na	6.1	0.9545	0.1613	8.7	-1	4.8	-1	35
K	2.7	0.7996	0.1999	5.5	-1	2.05	-1	16
Daylength	9'43"			10'30"		9'21"		

Table 113. SUMMARY CHART - BORON *12-15-70/2-9-71*
Test 7 Control

Chemical or physical analysis	X̄	SD ±	SE ±	Maximum	Minimum	N
Temp.	15.33°	3.319°	0.0943°	21.67° -1	7.22° -3	121
pH	8.036	0.356	0.000	9.0 -1	6.8 -2	25
NO_3-N	2.79	0.2050	0.0328	3.25 -1	2.25 -1	39
PO_4-P	0.110	0.0333	0.0050	0.190 -1	0.068 -1	44
NH_3-N	0.034	0.0185	0.0053	0.056 -1	<0.02 -2	12
SO_4	18.1	1.601	0.6535	19.9 -1	15.4 -1	6
SiO_2	11.9	2.218	0.3598	15.8 -1	6.8 -1	38
Alk-P	--	--	--	--	--	--
Alk-MO	50.6	3.43	0.78	57.0 -1	44.0 -2	19
Cl	14.0	3.57	1.46	18.0 -1	8.0 -1	6
Ca Hard.	52.5	4.46	1.82	56.0 -2	44.0 -1	6
Tot. Hard.	89.4	10.17	3.85	104.0 -1	80.0 -1	7
B	<0.05	--	--	<0.05 -	<0.05 -	23
Zn	--	--	--	--	--	--
Cu	--	--	--	--	--	--
Mn	0.112	0.0725	0.0112	0.346 -1	0.023 -2	42
Fe	0.19	0.0801	0.0132	0.39 -1	0.05 -1	37
Na	5.7	0.8240	0.1434	8.3 -1	4.0 -1	33
K	3.6	1.445	0.4008	6.9 -1	2.2 -1	13
Daylength	9'43"			10'30"	9'21"	

Table 114. SUMMARY CHART - BORON [illegible]-20-73/8-20-73
Test 1 1.0 mg/l Boron

Chemical or physical analysis		$\overline{X}$	SD ±	SE. ±	Maximum		Minimum		N
Temp.	°C	19.28°	3.76°	0.1389°	24.44°	-1	13.00°	-2	730
pH		—	—	—	—		—		—
NO_3-N	mg/l	1.79	0.5040	0.1126	2.77	-1	1.19	-1	20
PO_4-P	mg/l	0.057	0.0400	0.000	0.143	-1	0.006	-1	21
NH_3-N	mg/l	0.123	0.0583	0.0173	0.204	-1	0.036	-1	11
SO_4	mg/l	20.6	2.843	1.421	24.4	-1	18.0	-1	4
SiO_2	mg/l	6.7	2.611	0.5838	12.1	-1	2.0	-1	20
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	57.3	4.953	1.108	64.0	-3	48.0	-2	20
Cl	mg/l	10.1	0.5032	0.2515	10.8	-1	9.6	-1	4
Ca Hard.	mg/l	51.0	2.582	1.291	54.0	-1	48.0	-1	4
Tot. Hard.	mg/l	83.5	3.416	1.708	88.0	-1	80.0	-1	4
B	mg/l	1.09	0.0538	0.0141	1.19	-1	0.99	-1	13
Mn	mg/l	0.091	0.0728	0.0141	0.251	-1	0.014	-1	24
Fe	mg/l	0.09	0.0300	—	0.16	-1	0.04	-1	20
Na	mg/l	7.1	1.594	0.6508	8.9	-1	5.5	-1	6
K	mg/l	2.7	0.6252	0.2551	3.2	-1	1.8	-1	6
Daylength		14'06"			14'35"		13'33"		32

Table 115. SUMMARY CHART - BORON 7-20-73/8-20-73
Test 5 1.0 mg/l Boron

Chemical or physical analysis	$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	19.28°	3.76°	0.1389°	24.44°	-1	13.00°	-2	730
pH	---	---	---	---		---		---
NO_3-N	2.15	0.4300	0.0959	2.76	-1	1.47	-1	20
PO_4-P	0.068	0.0424	0.0000	0.139	-1	0.007	-1	21
NH_3-N	0.114	0.0574	0.0173	0.184	-1	0.024	-1	11
SO_4	20.1	3.258	1.629	24.7	-1	17.1	-1	4
SiO_2	10.5	2.536	0.5669	14.7	-1	3.8	-1	20
Alk-P	---	---	---	---		---		---
Alk-MO	55.1	3.523	0.7877	62.0	-1	48.0	-1	20
Cl	10.6	1.200	6.000	11.6	-2	9.2	-1	4
Ca Hard.	53.0	1.155	0.5773	54.0	-2	52.0	-2	4
Tot. Hard.	82.0	1.633	0.8164	84.0	-1	80.0	-1	4
B	1.10	0.0655	0.0173	1.20	-2	1.00	-1	13
Zn	---	---	---	---		---		---
Cu	---	---	---	---		---		---
Mn	0.090	0.0854	0.0173	0.294	-1	<0.005	-1	21
Fe	0.10	0.0374	---	0.18	-1	0.04	-1	20
Na	5.9	0.4130	0.1685	6.7	-1	5.5	-1	6
K	2.5	0.5316	0.2170	3.1	-1	1.9	-2	6
Daylength	14'06"			14'35"		13'33"		32

Table 116. SUMMARY CHART - BORON 7-20-73/8-20-73
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.28°	3.76°	0.1389°	24.44°	-1	13.33°	-2	730
pH		—	—	—	—		—		—
NO_3-N	mg/l	1.53	0.6443	0.1438	2.78	-1	0.59	-1	20
PO_4-P	mg/l	0.082	0.1392	0.0300	0.665	-1	0.005	-2	21
NH_3-N	mg/l	0.132	0.0632	0.0173	0.244	-1	0.028	-1	12
SO_4	mg/l	20.1	2.883	1.441	24.2	-1	17.5	-1	4
SiO_2	mg/l	7.2	2.671	0.5972	12.8	-1	2.2	-1	20
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	56.7	4.966	1.110	72.0	-1	50.0	-1	20
Cl	mg/l	9.7	0.3828	0.1913	10.0	-2	9.2	-1	4
Ca Hard.	mg/l	55.0	4.761	2.380	62.0	-1	52.0	-2	4
Tot. Hard.	mg/l	83.0	2.582	1.291	86.0	-1	80.0	-1	4
B	mg/l	0.05	0.0264	—	0.07	-3	<0.05	-2	10
Ni	µg/l	0.8	0.5099	0.1109	1.7	-1	<0.5	-4	21
Cu	mg/l	—	—	—	—		—		—
Mn	mg/l	0.091	0.0741	0.0141	0.260	-1	<0.005	-1	21
Fe	mg/l	0.07	0.0346	0.000	0.14	-1	<0.04	-2	20
Na	mg/l	6.2	0.7984	0.3258	7.8	-1	5.7	-2	6
K	mg/l	2.9	0.9352	0.3817	4.0	-1	1.8	-1	6
Daylength		14'06"			14'35"		13'33"		32

Table 117 SUMMARY CHART - NICKEL 3-29-71/4-29-71
Test 1 8.6 µg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.11°	5.151°	2.08°	26.67°	8.89°	28
pH		---	---	---	---	---	---
NO_3-N	mg/l	2.16	0.3391	0.0875	2.67 -1	1.68 -1	15
PO_4-P	mg/l	0.135	0.0412	0.0085	0.182 -1	0.014 -1	23
NH_3-N	mg/l	0.064	0.0141	0.0063	0.086 -1	0.042 -1	5
SO_4	mg/l	49.9	3.309	1.250	53.0 -1	43.5 -1	7
SiO_2	mg/l	11.51	1.908	0.4068	14.0 -1	4.7 -1	22
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	13.5	2.697	0.8130	20.0 -1	10.0 -2	11
Cl	mg/l	11.3	2.309	1.33	14.0 -1	10.0 -2	3
Ca Hard.	mg/l	51.3	5.033	2.906	56.0 -1	46.0 -1	3
Tot. Hard.	mg/l	88.0	10.58	6.110	100.0 -1	80.0 -1	3
V	mg/l	---	---	---	---	---	---
Ni	µg/l	8.6	1.808	0.3247	12.6 -1	6.0 -1	31
Zn	mg/l	---	---	---	---	---	---
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.119	0.0836	0.0145	0.304	0.028	32
Fe	mg/l	0.18	0.0554	0.0105	0.29	0.08	26
Na	mg/l	5.7	0.2082	0.1202	6.0	5.6	3
K	mg/l	3.3	0.7085	0.3169	4.3	2.4	5
Daylength		13'10"			13'48"	12'34"	

Table 118 SUMMARY CHART - NICKEL 3-29-71/4-29-71

Test 8 7.6 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.89°	5.89°	0.23°	27.22°	8.89°	639
pH		--	--	--	--	--	--
NO_3-N	mg/l	2.08	0.4085	0.0121	2.65 -2	1.45 -1	16
PO_4-P	mg/l	0.128	0.0538	0.0112	0.214 -1	0.005 -1	23
NH_3-N	mg/l	0.064	0.0173	0.0065	0.090 -2	0.048 -1	7
SO_4	mg/l	57.0	4.378	1.6547	63.5 -1	51.0 -1	7
SiO_2	mg/l	10.3	2.837	0.6344	17.4 -1	6.4 -1	20
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	9.54	4.845	1.461	16.0 -2	2.0 -1	11
Cl	mg/l	13.7	--	--	18.0 -1	11.0 -1	3
Ca Hard.	mg/l	52.0	--	--	56.0 -1	48.0 -1	3
Tot. Hard.	mg/l	87.0	--	--	88.0 -1	86.0 -1	2
V	mg/l	--	--	--	--	--	--
Ni	µg/l	7.6	2.197	0.3662	14.8 -1	3.8 -1	36
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.122	0.0974	0.0161	0.381	0.028	36
Fe	mg/l	0.14	0.0485	0.0089	0.25	0.09	27
Na	mg/l	5.8	0.3214	0.1856	6.0	5.4	3
K	mg/l	4.1	0.9834	0.4398	5.4	3.2	5
Daylength		13'10"			13'48"	12'34"	

Table 119 SUMMARY CHART - NICKEL 3-29-71 / 4-29-71
Test 5 4.78 µg/1 Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.83°	5.33°	0.21°	27.22°	9.44°	634
pH		—	—	—	—	—	—
NO_3-N	mg/1	2.16	0.3114	0.080	2.60 -2	1.68 -1	15
PO_4-P	mg/1	0.127	0.0374	0.0079	0.196 -1	0.005 -1	22
NH_3-N	mg/1	0.224	0.1865	0.0659	0.48 -1	0.026 -1	8
SO_4	mg/1	56.6	3.749	1.417	61.0 -1	51.0 -1	7
SiO_2	mg/1	11.12	2.933	0.625	14.8 -1	8.2 -1	21
Alk-P	mg/1	—	—	—	—	—	—
Alk-MO	mg/1	9.5	3.205	0.9663	14.0 -2	6.0 -3	11
Cl	mg/1	14.0	3.464	2.000	18.0 -1	12.0 -2	3
Ca Hard.	mg/1	50.7	2.309	1.333	52.0 -2	48.0 -1	3
Tot. Hard.	mg/1	98.7	15.535	8.969	116.0 -1	86.0 -1	3
V	mg/1	—	—	—	—	—	—
Ni	µg/1	4.78	1.098	0.2075	6.0 -2	2.1 -2	28
Zn	mg/1	—	—	—	—	—	—
Cu	mg/1	—	—	—	—	—	—
Mn	mg/1	0.136	0.1015	0.0187	0.329	0.036	29
Fe	mg/1	0.16	0.0379	0.0077	0.27	0.09	22
Na	mg/1	5.7	0.0577	0.0333	5.8	5.7	3
K	mg/1	4.3	0.4041	0.2333	4.8	4.1	3
Daylength		13'10"			13'48"	12'34"	

Table 120 SUMMARY CHART - NICKEL 3-29-71 /4-29-71
Test 7 4.54 µg/1 Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.44°	5.88°	0.22°	26.11°	7.22°	634
pH		—	—	—	—	—	—
NO_3-N	mg/1	2.04	0.312	0.081	2.48 -1	1.60 -1	15
PO_4-P	mg/1	0.112	0.0435	0.0092	0.194 -2	0.005 -1	22
NH_3-N	mg/1	0.067	0.0223	0.0084	0.098 -1	0.035 -1	7
SO_4	mg/1	53.5	5.508	2.082	61.5 -1	45.0 -1	7
SiO_2	mg/1	8.9	3.065	0.6688	16.1 -1	4.7 -1	21
Alk-P	mg/1	—	—	—	—	—	—
Alk-MO	mg/1	10.9	5.586	1.767	24.0 -1	4.0 -1	10
Cl	mg/1	14.7	2.309	1.333	16.0 -2	12.0 -1	3
Ca Hard.	mg/1	50.0	—	—	50.0 -	50.0 -	3
Tot. Hard.	mg/1	89.3	6.389	3.689	94.0 -1	82.0 -1	3
V	mg/1	—	—	—	—	—	—
Ni	µg/1	4.54	1.353	0.2430	9.1 -1	2.3 -1	31
Zn	mg/1	—	—	—	—	—	—
Cu	mg/1	—	—	—	—	—	—
Mn	mg/1	0.113	0.0906	0.0155	0.474	0.020	33
Fe	mg/1	0.17	0.0924	0.0184	0.46	0.09	25
Na	mg/1	5.8	0.0577	0.0333	5.8	5.7	3
K	mg/1	4.0	1.003	0.5017	5.1	3.1	4
Daylength		13'10"			13'48"	12'34"	

Table 121. SUMMARY CHART - NICKEL 3-29-71/4-29-71
Test 6 2.21 μg/l

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.66°	5.22°	0.21°	26.67°	11.67°	633
pH		—	—	—	—	—	—
NO_3-N	mg/l	2.39	0.855	0.214	2.64 -1	1.74 -1	16
PO_4-P	mg/l	0.142	0.0412	0.0085	0.202 -1	0.005 -1	23
NH_3-N	mg/l	0.063	0.0244	0.0099	0.100 -1	0.026 -1	6
SO_4	mg/l	56.1	5.247	1.983	64.0 -1	50.5 -1	7
SiO_2	mg/l	11.7	2.164	0.4722	13.8 -1	4.9 -1	21
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	7.2	3.43	0.9911	15.0 -1	4.0 -1	12
Cl	mg/l	11.3	1.1546	0.6666	12.0 -2	10.0 -1	3
Ca Hard.	mg/l	51.3	2.309	1.333	54.0 -1	50.0 -2	3
Tot. Hard.	mg/l	99.3	11.37	6.566	112.0 -1	90.0 -1	3
V	mg/l	—	—	—	—	—	—
Ni	μg/l	2.21	0.4264	0.0836	3.1 -1	1.4 -1	26
Zn	mg/l	—	—	—	—	—	—
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.123	0.0769	0.0148	0.304	0.043	26
Fe	mg/l	0.19	0.0377	0.0077	0.25	0.10	23
Na	mg/l	5.8	0.0577	0.0333	5.9	5.8	3
K	mg/l	3.3	0.5831	0.2915	4.1	2.7	4
Daylength		13'10"			13'48"	12'34"	

Table 122. SUMMARY CHART - NICKEL 3-29-71/4-29-71
Test 2 2 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.05	5.145^{o}	0.208^{o}	26.67	8.89	28
pH		--	--	--	--	--	--
NO_3-N	mg/l	2.06	0.4129	0.1066	2.76 -1	1.45 -1	15
PO_4-P	mg/l	0.110	0.0366	0.0076	0.153 -1	0.009 -1	23
NH_3-N	mg/l	0.052	0.0173	0.0070	0.084 -1	0.026 -1	6
SO_4	mg/l	57.5	3.214	1.215	64.0 -1	54.5 -1	7
SiO_2	mg/l	6.91	2.976	0.649	13.58 -1	2.6 -1	21
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	11.64	4.884	1.473	20.0 -1	6.0 -3	11
Cl	mg/l	12.0	--	--	12.0 -	12.0 -	3
Ca Hard.	mg/l	48.0	2.00	1.155	50.0 -1	46.0 -1	3
Tot. Hard.	mg/l	98.0	8.717	5.033	108.0 -1	92.0 -1	3
V	mg/l	--	--	--	--	--	--
Ni	µg/l	2.0	1.08	0.208	6.8 -1	0.7 -1	27
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.091	0.0602	0.0114	0.214	0.027	27
Fe	mg/l	0.15	0.0495	0.0100	0.25	0.07	24
Na	mg/l	6.2	0.2082	0.1202	6.4	6.0	3
K	mg/l	5.0	1.063	0.5313	6.1	3.8	4
Daylength		13'10"			13'48"	12'34"	

Table 123 SUMMARY CHART - NICKEL 3-29-71/4-29-71
Test 3 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.05°	5.174°	0.2088°	26.67°	10.00°	28
pH		--	--	--	--	--	--
NO_3-N	mg/1	2.03	0.4133	0.1067	2.69 -1	1.52 -1	15
PO_4-P	mg/1	0.109	0.0363	0.0076	0.166 -1	0.000 -1	23
NH_3-N	mg/1	0.055	0.0200	0.0075	0.088 -1	0.026 -1	7
SO_4	mg/1	53.7	2.160	0.882	56.5 -1	51.0 -1	6
SiO_2	mg/1	7.94	2.000	0.4264	10.8 -1	4.3 -1	22
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	10.0	4.0	1.154	16.0 -1	4.0 -1	2
Cl	mg/1	16.7	6.429	3.712	24.0 -1	12.0 -1	3
Ca Hard.	mg/1	50.1	1.155	0.6666	52.0 -2	50.0 -1	3
Tot. Hard.	mg/1	96.7	20.82	12.02	120.0 -1	80.0 -1	3
V	mg/1	--	--	--	--	--	--
Ni	µg/1	0.41	0.2805	0.0551	0.9 -2	<0.2 -4	26
Zn	mg/1	--	--	--	--	--	--
Cu	mg/1	--	--	--	--	--	--
Mn	mg/1	0.072	0.0379	0.0071	0.174	0.025	27
Fe	mg/1	0.11	0.0499	0.0100	0.22	< 0.03	24
Na	mg/1	5.7	6.557	0.3786	6.4	5.1	3
K	mg/1	3.9	1.124	0.5618	5.2	2.6	4
Daylength		13'10"			13'48"	12'34"	

Table 124. SUMMARY CHART - NICKEL 3-29-71/4-29-71

Test 4 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.00°	5.107°	0.2066°	27.22°	8.89°	28
pH		--	--	--	--	--	--
NO_3-N	mg/l	2.05	0.4863	0.1255	3.04 -1	1.43 -1	15
PO_4-P	mg/l	0.108	0.0401	0.0084	0.156 -1	0.005 -1	23
NH_3-N	mg/l	0.064	0.0284	0.0127	0.098 -1	0.026 -1	5
SO_4	mg/l	54.3	5.83	2.204	63.5 -1	48.0 -1	7
SiO_2	mg/l	8.19	4.0036	0.8535	16.02 -1	2.2 -1	22
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	13.8	6.740	1.946	28.0 -1	4.0 -1	12
Cl	mg/l	12.7	1.155	0.6666	14.0 -1	12.0 -2	3
Ca Hard.	mg/l	48.3	2.081	1.202	50.0 -1	46.0 -1	3
Tot. Hard.	mg/l	96.0	11.14	6.43	108.0 -1	86.0 -1	3
V	mg/l	--	--	--	--	--	--
Ni	µg/l	0.6	0.3838	0.0753	1.7 -1	0.2 -3	26
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.092	0.0679	0.0122	0.300	0.007	29
Fe	mg/l	0.16	0.0806	0.0158	0.40	0.03	25
Na	mg/l	5.7	0.6506	0.3756	6.4	5.1	3
K	mg/l	4.8	0.9626	0.4813	5.9	3.6	4
Daylength		13'10"			13'48"	12'34"	

Table 125. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 1 9.1 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.22°	3.95°	0.114°	25.00°	-1	12.22°	-2	53
pH		6.835	0.371	0.010	8.1	-3	6.1	-3	53
NO_3-N	mg/l	2.19	0.3966	0.0909	2.90	-1	1.63	-1	19
PO_4-P	mg/l	0.134	0.0506	0.0088	0.238	-2	0.068	-1	33
NH_3-N	mg/l	0.074	0.0404	0.0108	0.153	-1	0.000	-1	14
SO_4	mg/l	36.9	21.74	10.87	64.5	-1	15.1	-1	4
SiO_2	mg/l	13.7	2.852	0.5704	20.4	-1	9.8	-1	25
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	33.2	18.72	4.833	55.0	-1	6.0	-1	15
Cl	mg/l	10.5	1.000	0.500	12.0	-1	10.0	-3	4
Ca Hard.	mg/l	51.3	4.84	1.98	60.0	-1	46.0	-1	6
Tot. Hard.	mg/l	87.0	5.000	2.236	95.0	-1	82.0	-1	5
Ni	µg/l	9.1	1.719	0.2621	12.4	-1	4.6	-1	43
Zn	mg/l	--	--	--	--		--		--
Cu	mg/l	--	--	--	--		--		--
Mn	mg/l	0.135	0.0753	0.0119	0.321	-1	0.030	-1	40
Fe	mg/l	0.20	0.0621	0.0102	0.35	-1	0.10	-1	37
Na	mg/l	5.9	0.7637	0.4469	6.8	-1	5.3	-1	3
K	mg/l	2.5	0.2986	0.1493	2.8	-1	2.1	-1	4
Daylength		14'52"			14'59"		14'34"		

Table 126. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 8 -8.1 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.78°	5.002°	.1506°	25.56° -2	8.33° -1	53
pH		6.951	0.435	0.010	8.3 -1	6.0 -1	53
NO_3-N	mg/l	2.14	0.4746	0.0931	2.91 -1	1.46 -1	26
PO_4-P	mg/l	0.127	0.0454	0.0070	0.215 -1	0.049 -1	41
NH_3-N	mg/l	0.071	0.0408	0.0106	0.162 -1	0.000 -1	15
SO_4	mg/l	36.1	23.01	10.29	65.5 -1	14.6 -1	5
SiO_2	mg/l	10.8	3.295	0.5918	18.0 -1	2.9 -1	31
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	34.13	21.741	5.435	59.0 -1	4.0 -1	16
Cl	mg/l	10.4	2.967	1.327	14.0 -1	6.0 -1	5
Ca Hard.	mg/l	53.429	6.803	2.571	66.0 -1	46.0 -1	7
Tot. Hard.	mg/l	88.33	5.854	2.390	98.0 -1	82.0 -1	6
Ni	µg/l	8.1	1.968	.286	13.1 -1	3.1 -1	47
Zn	mg/l	---	---	---	---	---	---
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.141	0.0930	0.0132	0.353 -1	0.030 -1	50
Fe	mg/l	0.18	0.0678	0.0104	0.33 -1	0.05 -1	42
Na	mg/l	5.9	0.5686	0.3283	6.6 -1	5.5 -1	3
K	mg/l	3.4	0.8655	0.4328	4.4 -1	2.4 -1	4
Daylength		14'52"			14'59"	14'34"	

Table 127. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 7 5.1 µg/1 Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.50°	4.696°	0.1414°	25.00° -3	8.33° -1	53
pH		6.983	0.480	0.013	8.4 -1	6.0 -2	53
NO_3-N	mg/1	2.64	0.4467	0.0988	2.94 -1	1.45 -1	20
PO_4-P	mg/1	0.125	0.0573	0.0103	0.246 -1	0.052 -1	33
NH_3-N	mg/1	0.068	0.0466	0.0147	0.147 -1	0.000 -1	.0
SO_4	mg/1	36.5	19.8	9.900	57.5 -1	15.7 -1	4
SiO_2	mg/1	15.4	3.456	0.6913	21.9 -1	5.0 -1	25
Alk-P	mg/1	---	---	---	---	---	---
Alk-MO	mg/1	34.2	19.47	5.399	68.0 -1	8.0 -1	13
Cl	mg/1	8.5	1.915	0.9574	10.0 -2	6.0 -1	4
Ca Hard.	mg/1	54.8	5.762	2.577	62.0 -1	50.0 -2	5
Tot. Hard.	mg/1	90.0	5.477	2.4419	96.0 -1	82.0 -1	5
Ni	µg/1	5.1	1.127	.1879	7.1 -2	2.4 -1	36
Zn	mg/1	---	---	---	---	---	---
Cu	mg/1	---	---	---	---	---	---
Mn	mg/1	0.131	0.0909	0.0154	0.370 -1	0.010 -1	35
Fe	mg/1	0.19	0.0731	0.0125	0.32 -1	0.06 -1	34
Na	mg/1	5.9	0.7506	0.4333	6.7	5.2	3
K	mg/1	2.7	0.7544	0.3722	3.8	2.2	4
Daylength		14'52"			14'59"	14'34"	

Table 128. SUMMARY CHART - NICKEL 5-22-71/7- 31-71
Test 5 4.9 μg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.22	4.528°	0.1367°	24.44	-1	8.33	-1	53
pH		6.994	0.478	0.010	8.3	-2	6.1	-4	53
NO_3-N	mg/l	2.29	0.4030	0.0790	3.00	-1	1.70	-1	26
PO_4-P	mg/l	0.139	0.0509	0.0079	0.238	-1	0.065	-1	41
NH_3-N	mg/l	0.191	0.1586	0.0384	0.64	-1	0.039	-1	17
SO_4	mg/l	35.5	18.97	8.487	62.5	-1	18.2	-1	5
SiO_2	mg/l	15.6	2.541	0.4563	20.9	-1	9.5	-1	31
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	35.25	21.959	5.4897	70.0	-1	4.0	-1	16
Cl	mg/l	9.400	2.793	1.249	12.0	-2	6.0	-1	5
Ca Hard.	mg/l	51.14	6.309	2.385	62.0	-1	42.0	-1	7
Tot. Hard.	mg/l	90.67	10.25	4.185	108.0	-1	82.0	-2	6
Ni	μg/l	4.9	1.147	0.1769	6.8	-1	2.1	-1	42
Zn	mg/l	---	---	---	---		---		---
Cu	mg/l	---	---	---	---		---		---
Mn	mg/l	0.130	0.0849	0.0126	0.320	-1	0.025	-1	45
Fe	mg/l	0.19	0.0855	0.0137	0.38	-1	0.05	-1	39
Na	mg/l	6.2	0.5508	0.3197	6.8	-1	5.8	-1	3
K	mg/l	2.3	0.1293	0.0946	2.4	-1	2.3	-1	4
Daylength		14'52"			14'59"		14'34"		

Table 129. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 6 2.3 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.39°	4.679°	0.1410°	25.00°	-2	8.33°	-1	53
pH		7.005	0.492	0.010	8.3	-3	6.0	-1	53
NO_3-N	mg/l	2.18	0.4931	0.0967	3.09	-1	1.40	-1	26
PO_4-P	mg/l	0.136	0.0547	0.0086	0.258	-1	0.042	-1	41
NH_3-N	mg/l	0.0621	0.0339	0.0090	0.129	-1	0.020	-1	14
SO_4	mg/l	36.1	21.86	9.776	63.5	-1	16.0	-1	5
SiO_2	mg/l	13.1	2.541	0.4563	17.2	-1	5.1	-1	31
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	32.56	21.472	5.368	62.0	-1	4.0	-1	16
Cl	mg/l	10.2	2.49	1.14	14.0	-1	7.0	-1	5
Ca Hard.	mg/l	55.714	7.158	2.706	70.0	-1	50.0	-2	7
Tot. Hard.	mg/l	87.0	4.147	1.693	92.0	-1	80.0	-1	6
Ni	µg/l	2.3	0.5895	0.0921	3.9	-1	1.6	-1	41
Zn	mg/l	---	---	---	---		---		---
Cu	mg/l	---	---	---	---		---		---
Mn	mg/l	0.155	0.1041	0.0161	0.402	-1	0.045	-1	42
Fe	mg/l	0.18	0.0741	0.0118	0.32	-1	0.05	-1	39
Na	mg/l	10.6	8.983	4.492	24.0	-1	5.5	-1	4
K	mg/l	3.0	0.7089	0.3544	3.9	-1	2.4	-1	4
Daylength		14'52"			14'59"		14'34"		

Table 130. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 2 2.2 µg/l

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.56°	4.087°	0.1178°	25.56°	-1	11.67°	-1	53
pH		6.845	0.406	0.010	8.2	-2	6.0	-3	53
NO_3-N	mg/l	2.12	0.4443	0.0871	3.03	-1	1.39	-1	26
PO_4-P	mg/l	0.115	0.0469	0.0073	0.212	-1	0.042	-1	41
NH_3-N	mg/l	0.059	0.0030	0.0091	0.124	-1	0.000	-1	13
SO_4	mg/l	31.9	21.62	9.670	65.0	-1	15.1	-1	5
SiO_2	mg/l	10.1	3.106	0.5578	14.6	-1	1.0	-1	31
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	37.188	21.349	5.3371	61.0	-1	4.0	-1	16
Cl	mg/l	11.0	2.449	1.0954	14.0	-1	8.0	-1	5
Ca Hard.	mg/l	54.571	4.429	1.674	60.0	-1	46.0	-1	7
Tot. Hard.	mg/l	93.5	8.843	3.613	108.0	-1	86.0	-2	6
Ni	µg/l	2.2	0.5272	.0813	3.4	-1	1.2	-1	42
Zn	mg/l	---	--	--	--		--		--
Cu	mg/l	--	--	--	--		--		--
Mn	mg/l	0.056	0.0776	0.0118	0.312	-1	0.00	-1	43
Fe	mg/l	0.20	0.0685	0.0107	0.39	-1	0.07	-1	41
Na	mg/l	6.4	1.400	0.8083	8.0	-1	5.4	-1	3
K	mg/l	3.1	0.4796	0.2398	3.5	-1	2.35	-1	4
Daylength		14'52"			14'59"		14'34"		

Table 131. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 3 - Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	16.61°	4.169°	0.1200°	25.56°	-1	11.67°	-1	53
pH		6.899	0.424	0.010	8.3	-1	6.0	-1	53
NO_3-N	mg/l	2.68	2.769	0.5537	2.96	-1	1.50	-1	25
PO_4-P	mg/l	0.118	0.0408	0.0064	0.203	-1	0.046	-1	41
NH_3-N	mg/l	0.059	0.0279	0.0080	0.100	-1	0.000	-1	12
SO_4	mg/l	33.7	20.72	9.268	66.0	-1	16.7	-1	5
SiO_2	mg/l	11.2	3.323	0.5969	16.2	-1	10.0	-1	31
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	36.125	18.261	4.561	60.0	-1	6.0	-1	16
Cl	mg/l	10.6	2.408	1.077	14.0	-1	8.0	-1	5
Ca Hard.	mg/l	49.714	7.158	2.706	64.0	-1	44.0	-3	7
Tot. Hard.	mg/l	89.0	5.899	2.408	96.0	-1	80.0	-1	6
Ni	µg/l	0.8	0.2904	0.0443	1.6	-1	0.4	-5	43
Zn	mg/l	--	--	--	--		--		--
Cu	mg/l	--	--	--	--		--		--
Mn	mg/l	0.155	0.0924	0.0141	0.361	-1	0.020	-1	43
Fe	mg/l	0.19	0.0656	0.0105	0.31	-1	0.06	-1	39
Na	mg/l	3.1	0.8655	0.4328	4.2	-1	2.26	-1	4
K	mg/l	6.0	0.5859	0.3383	6.7	-1	5.6	-1	3
Daylength		14'52"			14'59"		14'34"		

Table 132. SUMMARY CHART - NICKEL 5-22-71/7-31-71
Test 4 - Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.94°	4.352°	0.1260°	26.11° -1	11.67° -1	53
pH		6.889	0.391	0.010	8.3 -1	6.0 -1	53
NO_3-N	mg/l	2.11	0.4577	0.1023	2.88 -1	1.47 -1	20
PO_4-P	mg/l	0.119	0.0424	0.0074	0.208 -1	0.052 -1	33
NH_3-N	mg/l	0.070	0.0436	0.0145	0.1381 -1	0.020 -2	9
SO_4	mg/l	35.8	21.81	10.91	66.0 -1	17.3 -1	4
SiO_2	mg/l	11.9	2.331	0.4663	16.2 -1	7.4 -1	25
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	35.7	19.75	5.28	70.0 -1	6.0 -1	14
Cl	mg/l	9.25	1.500	0.7500	10.0 -3	7.0 -1	4
Ca Hard.	mg/l	51.7	7.089	2.894	62.0 -1	40.0 -1	6
Tot. Hard.	mg/l	85.6	4.34	1.94	92.0 -1	82.0 -2	5
Ni	µg/l	0.8	0.2820	0.0457	1.6 -1	0.4 -3	38
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.109	0.0598	0.0099	0.326 -1	0.030 -1	36
Fe	mg/l	0.21	0.0625	0.0107	0.33 -3	0.09 -1	34
Na	mg/l	6.5	0.6244	0.3606	7.0 -1	5.8 -1	3
K	mg/l	2.8	0.3109	0.1554	3.0 -1	2.25 -1	4
Daylength		14'52"			14'59"	14'34"	

Table 133. SUMMARY CHART - NICKEL 11-5-71/12-12-71
Test 1 1 mg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.55°	1.7°	0.3°	23.61°	-4	16.39°	-8	38
pH		7.92	0.31	0.04	8.8	-4	6.8	-1	38
NO_3-N	mg/l	3.29	0.4105	0.0838	3.73	-1	2.21	-1	24
PO_4-P	mg/l	0.101	0.0346	0.0069	0.192	-1	0.039	-1	25
NH_3-N	mg/l	0.11	0.0923	0.0256	0.29	-1	<0.02	-1	13
SO_4	mg/l	22.4	5.576	1.681	36.4	-1	16.9	-1	11
SiO_2	mg/l	16.5	1.416	0.2953	19.4	-1	14.2	-1	23
Alk-P	mg/l	--	--	--	--		--		--
Alk-MO	mg/l	53.6	2.755	0.5744	59.8	-1	50.0	-3	23
Cl	mg/l	11.3	2.066	0.8433	14.0	-1	8.0	-1	6
Ca Hard.	mg/l	55.6	2.607	1.166	58.0	-2	52.0	-1	5
Tot. Hard.	mg/l	113.0	9.309	4.654	122.0	-1	104.0	-1	4
V	mg/l	--	--	--	<0.1	-	<0.1	-	6
Ni	mg/l	1.04	0.1279	0.0233	1.30	-1	0.80	-1	33
Zn	mg/l	0.025	0.0049	0.0035	0.028	-	0.021	-	2
Cu	mg/l	0.021	0.0127	0.0090	0.030	-	0.012	-	2
Mn	mg/l	0.29	0.1261	0.0222	0.66	-1	0.101	-1	32
Fe	mg/l	0.21	0.1741	0.0335	0.96	-1	0.07	-1	27
Na	mg/l	6.43	0.5559	0.1758	7.3	-1	5.4	-1	10
K	mg/l	3.58	0.7368	0.2330	4.8	-1	2.5	-1	10
Daylength		9'47"			10'21"		9'23"		

Table 134. SUMMARY CHART - NICKEL 11-5-71/12-12-71
Test 2 0.5 mg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	20.11°	2.0°	0.3°	25.83	-2	16.67	-8	38
pH		7.96	0.30	0.04	8.8	-1	6.7	-1	38
NO_3-N	mg/l	2.97	0.3049	0.0623	3.31	-1	1.81	-1	24
PO_4-P	mg/l	0.089	0.0197	0.0039	0.134	-1	0.059	-1	25
NH_3-N	mg/l	0.102	0.0944	0.0261	0.35	-1	0.0248	-1	13
SO_4	mg/l	23.3	4.435	1.337	33.8	-1	19.5	-1	11
SiO_2	mg/l	15.6	1.229	0.2564	17.9	-1	13.6	-1	23
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	53.0	3.017	0.6291	60.0	-1	48.0	-1	23
Cl	mg/l	12.3	1.506	0.6146	14.0	-2	10.0	-1	6
Ca Hard.	mg/l	50.4	3.847	1.720	56.0	-1	46.0	-1	5
Tot. Hard.	mg/l	100.0	6.733	3.367	108.0	-1	92.0	-1	4
V	mg/l	---	---	---	<0.1	-	<0.1	-	6
Ni	mg/l	0.50	0.0735	0.0130	0.68	-1	0.34	-1	32
Zn	mg/l	0.017	0.0021	0.0015	0.018	-	0.015	-	2
Cu	mg/l	0.011	0.0007	0.0004	0.011	-	0.010	-	2
Mn	mg/l	0.237	0.1344	0.0238	0.570	-1	0.044	-1	32
Fe	mg/l	0.20	0.1586	0.0305	0.91	-1	0.08	-1	27
Na	mg/l	6.43	0.5559	0.1757	7.2	-1	5.5	-1	10
K	mg/l	3.87	1.003	0.3171	5.4	-1	2.9	-2	10
Daylength		9'47"			10'21"		9'23"		

Table 135. SUMMARY CHART - NICKEL 11-5-71/12-12-71
Test 3 0.05 mg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	20.78°	2.2°	0.3°	25.83° -4	15.28° -4	38
pH		7.74	0.18	0.00	9.1 -1	6.5 -1	38
NO_3-N	mg/l	2.68	0.5148	0.1051	3.39 -1	1.07 -1	24
PO_4-P	mg/l	0.095	0.0341	0.0068	0.163 -1	0.033 -1	25
NH_3-N	mg/l	0.084	0.0687	0.0191	0.22 -1	<0.02 -2	13
SO_4	mg/l	25.9	6.890	2.077	43.2 -1	18.9 -1	11
SiO_2	mg/l	14.3	3.951	0.8238	20.3 -1	9.0 -1	23
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	51.2	2.937	0.6124	56.0 -3	46.0 -1	23
Cl	mg/l	11.3	2.422	0.9888	14.0 -2	8.0 -1	6
Ca Hard.	mg/l	54.0	8.831	3.949	66.0 -1	42.0 -1	5
Tot. Hard.	mg/l	95.5	5.259	2.629	100.0 -3	90.0 -1	4
V	mg/l	—	—	—	<0.1 -	<0.1 -	6
Ni	mg/l	0.05	0.0146	0.0025	0.09 -1	0.03 -8	33
Zn	mg/l	0.014	0.0021	0.0015	0.015 -	0.012 -	2
Cu	mg/l	0.008	—	—	0.008 -	0.008 -	2
Mn	mg/l	0.123	0.0685	0.0121	0.255 -1	0.010 -1	32
Fe	mg/l	0.16	0.1170	0.0225	0.67 -1	0.08 -1	27
Na	mg/l	6.33	0.5121	0.1619	6.9 -1	5.4 -1	10
K	mg/l	3.35	0.3647	0.1153	3.9 -1	2.95 -1	10
Daylength		9'47"			10'21"	9'23"	

Table 136. SUMMARY CHART - NICKEL 11-5-71 12-12-71
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	21.27°	2.1°	0.3°	26.39°	-4	15.00°	-4	38
pH		7.50	0.32	0.04	8.8	-2	6.5	-1	38
NO_3-N	mg/l	2.73	0.4227	0.0860	3.25	-1	1.13	-1	24
PO_4-P	mg/l	0.105	0.0423	0.0084	0.189	-1	0.046	-1	25
NH_3-N	mg/l	0.089	0.0703	0.0195	0.248	-1	0.020	-2	13
SO_4	mg/l	26.7	7.658	2.309	44.4	-1	18.5	-1	11
SiO_2	mg/l	15.5	3.899	0.8129	21.3	-1	7.8	-1	23
Mg	mg/l	7.91	0.0566	0.0400	7.95	-	7.87	-	2
Alk-MO	mg/l	51.9	6.321	1.318	66.0	-1	44.0	-2	23
Cl	mg/l	11.3	1.633	0.6666	14.0	-1	10.0	-2	6
Ca Hard.	mg/l	56.0	4.000	1.788	60.0	-1	50.0	-1	5
Tot. Hard.	mg/l	98.0	5.889	2.944	104.0	-1	90.0	-1	4
V	mg/l	--	--	--	<0.1	-	<0.1	-	32
Ni	mg/l	--	--	--	<0.03	-	<0.03	-	31
Zn	mg/l	0.012	0.0028	0.0020	0.014	-1	0.01	-1	2
Cu	mg/l	0.008	--	--	0.008	-1	0.008	-1	2
Mn	mg/l	0.084	--	--	0.237	-1	0.025	-2	32
Fe	mg/l	0.16	0.1170	0.0225	0.59	-1	0.06	-1	27
Na	mg/l	7.86	2.161	0.6833	12.5	-1	5.4	-1	10
Ca	mg/l	22.5	0.7778	0.5500	23.0	-1	21.9	-1	2
K	mg/l	3.01	0.3229	0.1076	3.6	-1	2.7	-2	9
Daylength		9'47"			10'21"		9'23"		

Table 137. SUMMARY CHART - NICKEL 2-1-72/3-11-72
Test 7 1 mg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	18.66°	—	—	23.89°		12.78°		41
pH		7.505	0.266	0.042	9.0	-2	6.8	-9	40
NO_3-N	mg/l	3.33	0.5501	0.1100	4.12	-1	2.33	-1	25
PO_4-P	mg/l	0.100	0.0318	0.0058	0.165	-1	0.042	-1	29
NH_3-N	mg/l	0.062	0.0572	0.0153	0.183	-1	$<$0.02	-2	14
SO_4	mg/l	18.5	1.658	0.5861	20.9	-1	16.7	-1	8
SiO_2	mg/l	12.6	2.952	0.5483	15.9	-2	6.6	-1	29
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	46.5	4.752	0.9319	54.0	-1	28.0	-1	26
Cl	mg/l	11.2	1.687	0.533	14.0	-2	10.0	-6	10
Ca Hard.	mg/l	48.4	2.157	0.6505	50.0	-6	44.0	-1	11
Tot. Hard.	mg/l	147.5	90.77	32.09	332.0	-1	76.0	-1	8
V	mg/l	$<$0.10			$<$0.10	-	$<$0.10	-	13
Ni	mg/l	1.07	0.1306	0.0195	1.33	-1	0.57	-1	45
Zn	mg/l	0.013	0.0035	0.0010	0.016	-2	0.006	-1	7
Cu	mg/l	$<$0.005	—	—	$<$0.005	-	$<$0.005	-	4
Mn	mg/l	0.166	0.0691	0.0110	0.314	-1	0.040	-1	39
Fe	mg/l	0.16	0.0731	0.0127	0.49	-1	0.07	-1	33
Na	mg/l	5.7	0.3891	0.1079	6.1	-2	4.9	-1	13
K	mg/l	2.8	0.8794	0.2018	4.8	-1	1.9	-1	19
Daylength		10'55"			11'43"		10'08"		41

Table 138. SUMMARY CHART - NICKEL 2-1-72/3-11-72
Test 2 .47 mg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.66°	—	—	22.78°	13.33°	41
pH		7.795	0.0184	0.00	9.0 -5	6.4 -1	40
NO_3-N	mg/l	2.87	0.6972	0.1394	3.75 -1	1.57 -1	25
PO_4-P	mg/l	0.077	0.0294	0.0054	0.130 -1	0.033 -1	29
NH_3-N	mg/l	0.049	0.0470	0.0126	0.180 -1	< 0.02 -2	14
SO_4	mg/l	18.7	1.309	0.4629	21.2 -1	17.6 -1	8
SiO_2	mg/l	12.2	3.498	0.6495	16.0 -1	4.9 -1	29
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	46.6	4.262	0.8359	54.0 -1	30.0 -1	26
Cl	mg/l	10.4	2.459	0.7774	14.0 -1	6.0 -1	10
Ca Hard.	mg/l	49.3	3.495	1.054	54.0 -2	44.0 -1	11
Tot. Hard.	mg/l	113.3	41.47	14.66	212.0 -1	82.0 -1	8
V	mg/l	< 0.10	—	—	< 0.10 -	< 0.10 -	13
Ni	mg/l	0.47	0.0858	0.0129	0.64 -2	0.21 -1	44
Zn	mg/l	0.011	0.0055	0.0020	0.017 -1	< 0.005 -1	7
Cu	mg/l	< 0.005	—	—	< 0.005 -	< 0.005 -	4
Mn	mg/l	0.155	0.0948	0.0151	0.408 -1	0.011 -1	39
Fe	mg/l	0.15	0.1086	0.0189	0.67 -1	0.03 -1	33
Na	mg/l	5.6	0.3282	0.0910	6.0 -2	5.0 -1	13
K	mg/l	3.1	1.195	0.2672	5.2 -1	1.85 -1	20
Daylength		10'55"			11'43"	10'08"	41

Table 139. SUMMARY CHART - NICKEL 2-1-72/3-11-72
Test 3 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.66°	—	—	23.89°	13.33°	41
pH		7.838	0.311	0.044	9.1 -1	6.5 -3	40
NO_3-N	mg/1	2.52	0.4479	0.0896	3.46 -1	1.95 -1	25
PO_4-P	mg/1	0.096	0.0617	0.0114	0.235 -1	0.016 -1	29
NH_3-N	mg/1	0.043	0.0533	0.0142	0.162 -1	<0.02 -6	14
SO_4	mg/1	20.0	2.625	0.9282	24.7 -1	17.1 -1	8
SiO_2	mg/1	10.3	3.018	0.5604	16.1 -1	5.4 -1	29
Alk-P	mg/1	00.0	—	—	00.0	00.0	—
Alk-MO	mg/1	47.3	4.746	0.9308	58.0 -1	38.0 -2	26
Cl	mg/1	10.8	1.932	0.6110	14.0 -1	8.0 -2	10
Ca Hard.	mg/1	48.9	3.506	1.057	56.0 -1	44.0 -2	11
Tot. Hard.	mg/1	86.3	8.031	2.839	98.0 -1	78.0 -2	8
V	mg/1	<0.10	—	—	<0.10 -	<0.10 -	15
Ni	mg/1	<0.03	—	—	<0.03 -	<0.03 -	18
Zn	mg/1	7.011	0.0057	0.0020	<0.017 -1	<0.005 -1	7
Cu	mg/1	<0.005	—	—	<0.005 -	<0.005 -	4
Mn	mg/1	0.126	0.1145	0.0179	0.461 -1	0.016 -1	41
Fe	mg/1	0.14	0.1076	0.0190	0.68 -1	0.05 -1	32
Na	mg/1	5.8	0.3550	0.0935	6.2 -2	5.0 -1	13
K	mg/1	3.5	0.9915	0.2275	4.8 -1	1.85 -1	19
Daylength		10'55"			11'43"	10'08"	41

Table 140. SUMMARY CHART - NICKEL 2-1-72/3-11-72
Test 5 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	18.66°	--	--	24.44°		10.56°		41
pH		7.700	0.353	0.056	9.0	-8	7.0	-2	40
NO_3-N	mg/l	2.58	0.4502	0.0900	3.44	-1	1.94	-1	25
PO_4-P	mg/l	0.093	0.0566	0.0105	0.241	-1	0.033	-2	29
NH_3-N	mg/l	0.049	0.0486	0.0129	0.159	-1	<0.02	-4	14
SO_4	mg/l	19.9	2.651	0.9373	23.6	-1	16.7	-1	8
SiO_2	mg/l	10.5	2.646	0.4914	16.0	-1	6.4	-1	29
Alk-P	mg/l	00.0	--	--	00.0	-	00.0	-	26
Alk-MO	mg/l	47.1	4.907	0.9622	62.0	-1	34.0	-1	26
Cl	mg/l	11.2	1.687	0.5333	14.0	-1	10.0	-6	10
Ca Hard.	mg/l	48.2	2.442	0.7363	50.0	-6	44.0	-2	11
Tot. Hard.	mg/l	84.0	5.952	2.104	96.0	-1	78.0	-2	8
V	mg/l	<0.10	--	--	<0.10	-	<0.10	-	14
Ni	mg/l	<0.03	--	--	<0.03	-	<0.03	-	17
Zn	mg/l	0.010	0.0057	0.0020	0.015	-2	<0.005	-2	7
Cu	mg/l	<0.005	--	--	<0.005	-	<0.005	-	4
Mn	mg/l	0.135	0.1366	0.0213	0.501	-1	0.029	-1	41
Fe	mg/l	0.15	0.0944	0.0167	0.60	-1	0.05	-1	32
Na	mg/l	5.7	0.3662	0.1016	6.2	-1	4.9	-1	13
K	mg/l	3.62	1.136	0.2605	5.3	-1	1.9	-1	19
Daylength		10'55"			11'43"		10'08"		41

Table 141. SUMMARY CHART - NICKEL 7-20-73/8-20-73
Test 2 43.3 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.28°	3.76°	0.1389°	24.44° -1	13.33° -1	730
pH		--	--	--	--	--	--
NO_3-N	mg/l	1.94	0.6924	0.1587	2.94 -1	1.10 -1	19
PO_4-P	mg/l	0.078	0.0509	0.0100	0.170 -1	0.010 -2	21
NH_3-N	mg/l	0.118	0.0583	0.0141	0.188 -1	0.028 -1	12
SO_4	mg/l	19.8	1.427	0.7135	21.7 -1	18.5 -1	4
SiO_2	mg/l	8.8	3.722	0.8322	17.1 -1	3.2 -2	20
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	56.2	3.722	0.8322	62.0 -2	50.0 -3	20
Cl	mg/l	11.3	1.829	0.9146	13.2 -1	9.2 -1	4
Ca Hard.	mg/l	51.5	1.000	0.5000	52.0 -3	50.0 -1	4
Tot. Hard.	mg/l	85.0	4.761	2.380	90.0 -1	80.0 -1	4
Ni	µg/l	43.3	18.66	3.979	82.0 -1	9.6 -1	22
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.226	0.2078	0.0447	0.88 -1	<0.005 -1	21
Fe	mg/l	0.16	0.0800	0.0173	0.31 -1	<0.04 -1	20
Na	mg/l	6.6	1.786	0.7292	9.7 -1	5.3 -1	6
K	mg/l	2.9	0.9005	0.3675	4.0 -1	1.8 -1	6
Daylength		14'06"			14'35"	13'33"	32

Table 142. SUMMARY CHART - NICKEL 7-20-73/8-20-73
Test 6 36.5 µg/l Ni

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.28°	3.76°	0.1389°	24.44° -1	13.33° -1	730
pH		---	---	---	---	---	--
NO_3-N	mg/l	1.75	0.7961	0.1777	3.52 -1	0.97 -1	20
PO_4-P	mg/l	0.075	0.1153	0.0244	0.548 -1	0.006 -1	21
NH_3-N	mg/l	0.128	0.0984	0.0282	0.388 -1	<0.020 -1	12
SO_4	mg/l	19.6	2.326	1.163	22.4 -1	17.0 -1	4
SiO_2	mg/l	7.6	3.538	0.7912	14.6 -1	0.6 -1	20
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	58.2	3.183	0.7118	64.0 -2	52.0 -1	20
Cl	mg/l	10.5	0.8246	0.4123	11.2 -2	9.6 -1	4
Ca Hard.	mg/l	52.5	6.403	3.202	62.0 -1	48.0 -1	4
Tot. Hard.	mg/l	91.5	9.849	4.924	106.0 -1	84.0 -1	4
Ni	µg/l	36.5	14.60	3.113	72.0 -1	9.0 -1	22
Zn	mg/l	---	---	---	---	---	---
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.115	0.0761	0.0141	0.269 -1	<0.005 -1	21
Fe	mg/l	0.10	0.0469	0.0100	0.20 -1	<0.04 -1	20
Na	mg/l	6.2	1.134	0.4630	7.7 -1	5.1 -1	6
K	mg/l	2.7	0.8885	0.3627	3.8 -1	1.8 -1	6
Daylength		14'06"			14'35"	13'33"	32

Table 143. SUMMARY CHART - NICKEL 7-20-73/8-20-73
Test 3 6.4 μg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.28°	3.76°	0.1389°	24.44°	-1	13.33°	-1	730
pH		---	---	---	---		---		---
NO_3-N	mg/l	1.70	0.6003	0.1341	2.69	-1	1.02	-1	20
PO_4-P	mg/l	0.057	0.0331	0.0000	0.119	-1	0.008	-1	21
NH_3-N	mg/l	0.116	0.0591	0.0141	0.204	-1	<0.020	-1	12
SO_4	mg/l	20.3	2.351	1.176	23.4	-1	18.01		4
SiO_2	mg/l	8.5	2.553	0.5708	13.5	-1	3.8	-1	20
Alk-P	mg/l	---	---	---	---		---		---
Alk-MO	mg/l	55.7	3.130	0.7000	62.0	-2	50.0	-1	20
Cl	mg/l	9.5	0.3828	0.1913	10.0	-1	9.2	-2	4
Ca Hard.	mg/l	53.5	5.774	2.872	62.0	-1	50.0	-2	4
Tot. Hard.	mg/l	84.5	1.915	0.9573	86.0	-2	82.0	-1	4
Ni	μg/l	6.4	1.726	0.3598	9.6	-1	2.1	-1	23
Zn	mg/l	---	---	---	---		---		---
Cu	mg/l	---	---	---	---		---		---
Mn	mg/l	0.087	0.0692	0.0141	0.251	-1	0.016	-1	20
Fe	mg/l	0.09	0.0282	0.000	0.16	-1	0.04	-1	19
Na	mg/l	6.1	0.6473	0.2641	7.3	-1	5.6	-1	6
K	mg/l	2.7	0.6794	0.2773	3.3	-1	1.8	-1	6
Daylength		14'06"			14'35"		13'33"		32

Table 144. SUMMARY CHART -NICKEL 7-20-73/8-20-73
Test 7 5.9 μg/l Ni

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	19.28°	3.76°	0.1389	24.44° -1	13.33° -1	730
pH		—	—	—	—	—	—
NO_3-N	mg/l	1.59	0.695	0.1552	2.93 -1	0.79 -1	20
PO_4-P	mg/l	0.073	0.1178	0.0244	0.564 -1	<0.003 -1	21
NH_3-N	mg/l	0.119	0.0538	0.0141	0.208 -1	0.028 -1	12
SO_4	mg/l	20.3	2.421	1.210	23.3 -1	17.5 -1	4
SiO_2	mg/l	6.7	3.196	0.7147	12.7 -1	1.4 -1	20
Alk-P	mg/l	—	—	—	—	—	—
Alk-MO	mg/l	57.3	4.644	1.038	64.0 -2	44.0 -1	20
Cl	mg/l	10.1	0.200	0.100	10.4 -1	10.0 -3	4
Ca Hard.	mg/l	52.5	3.000	1.500	56.0 -1	50.0 -2	4
Tot. Hard.	mg/l	81.5	1.915	0.9573	84.0 -1	80.0 -2	4
Ni	μg/l	5.9	2.033	0.4546	10.0 -1	2.7 -1	20
Zn	mg/l	—	—	—	—	—	—
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.079	0.0830	0.0173	0.276 -1	0.005 -1	19
Fe	mg/l	0.07	0.0387	0.000	0.16 -1	<0.04 -1	18
Na	mg/l	6.9	1.630	0.6655	9.7 -1	5.7 -1	6
K	mg/l	3.1	1.084	0.4423	4.3 -1	1.8 -1	6
Daylength		14'06"			14'35"	13'33"	32

Table 145. SUMMARY CHART - NICKEL 7-20-73/8-20-73
Test 8 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum		Minimum		N
Temp.	°C	19.28°	3.76°	0.1389°	24.44°	-1	13.33°	-2	730
pH		—	—	—	—		—		—
NO_3-N	mg/l	1.53	0.6443	0.1438	2.78	-1	0.59	-1	20
PO_4-P	mg/l	0.082	0.1392	0.0300	0.665	-1	0.005	-2	21
NH_3-N	mg/l	0.132	0.0632	0.0173	0.244	-1	0.028	-1	12
SO_4	mg/l	20.1	2.883	1.441	24.2	-1	17.5	-1	4
SiO_2	mg/l	7.2	2.671	0.5972	12.8	-1	2.2	-1	20
Alk-P	mg/l	—	—	—	—		—		—
Alk-MO	mg/l	56.7	4.966	1.110	72.0	-1	50.0	-1	20
Cl	mg/l	9.7	0.3828	0.1913	10.0	-2	9.2	-1	4
Ca Hard.	mg/l	55.0	4.761	2.380	62.0	-1	52.0	-2	4
Tot. Hard.	mg/l	83.0	2.582	1.291	86.0	-1	80.0	-1	4
B	mg/l	0.05	0.0264	—	0.07	-3	<0.05	-2	10
Ni	µg/l	0.8	0.5099	0.1109	1.7	-1	<0.5	-4	21
Cu	mg/l	—	—	—	—		—		—
Mn	mg/l	0.091	0.0741	0.0141	0.260	-1	<0.005	-1	21
Fe	mg/l	0.07	0.0346	0.000	0.14	-1	<0.04	-2	20
Na	mg/l	6.2	0.7984	0.3258	7.8	-1	5.7	-2	6
K	mg/l	2.9	0.9352	0.3817	4.0	-1	1.8	-1	6
Daylength		14'06"			14'35"		13'33"		32

Table 146. SUMMARY CHART - RUBIDIUM 6-30-72/7-18-72
Test 5 1.03 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	17.67°	--	--	26.67° -1	10.56° -1	19
pH		7.518	0.385	0.017	8.7 -3	7.0 -26	19
NO_3-N	mg/l	2.17	0.2742	0.0867	2.55 -1	1.68 -1	10
PO_4-P	mg/l	0.062	0.0297	0.0089	0.122 -1	0.023 -2	11
NH_3-N	mg/l	0.134	0.0817	0.0333	0.210 -1	<0.02 -1	6
SO_4	mg/l	20.8	--	--	22.6 -1	18.9 -1	2
SiO_2	mg/l	10.8	2.297	0.7265	15.0 -1	7.9 -1	10
Alk-P	mg/l	2.0	--	--	2.0 -	2.0 -	10
Alk-MO	mg/l	51.0	3.460	1.094	56.0 -1	45.6 -2	10
Cl	mg/l	9.9	--	--	9.9 -	9.9 -	1
Ca Hard.	mg/l	57.5	--	--	59.0 -1	56.0 -1	2
Tot. Hard.	mg/l	82.1	--	--	82.2 -1	82.0 -1	2
Rb	mg/l	1.03	0.0330	0.0077	1.08 -1	0.97 -1	16
Zn	mg/l	—	—	—	—	—	—
Cu	mg/l	—	—	—	—	—	—
Mn	mg/l	0.070	0.0594	0.0148	0.196 -1	0.019 -1	16
Fe	mg/l	0.13	0.0504	0.0138	0.27 -1	0.07 -1	13
Na	mg/l	5.7	0.4615	0.2064	6.3 -1	5.2 -1	5
K	mg/l	2.5	0.4159	0.1860	3.1 -1	2.1 -1	5
Daylength		14'50"			14'58"	14'40"	

Table 147. SUMMARY CHART - RUBIDIUM 6-30-72/7-18-72
Test 1 0.10 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.55°	--	--	25.56° -1	13.89° -2	19
pH		7.843	0.440	0.020	8.8 -6	7.0 -1	19
NO_3-N	mg/l	2.12	0.3462	0.1095	2.81 -1	1.63 -1	10
PO_4-P	mg/l	0.059	0.0207	0.0062	0.104 -1	0.029 -1	11
NH_3-N	mg/l	0.119	0.0979	0.0339	0.288 -1	<0.02 -1	6
SO_4	mg/l	20.2	--	--	21.5 -1	18.9 -1	2
SiO_2	mg/l	9.8	2.834	0.8960	15.6 -1	6.4 -1	10
Alk-P	mg/l	3.0	--	--	3.0 -	3.0 -	10
Alk-MO	mg/l	50.9	3.811	1.205	57.8 -1	45.8 -1	10
Cl	mg/l	9.7	--	--	9.7 -	9.7 -	1
Ca Hard.	mg/l	45.0	--	--	48.0 -1	43.6 -1	2
Tot. Hard.	mg/l	82.0	--	--	82.0 -	82.0 -	2
Rb	mg/l	0.104	0.0077	0.0000	0.120 -1	0.090 -1	16
Zn	mg/l	--	---	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.089	0.0639	0.0158	0.146 -2	0.022 -1	16
Fe	mg/l	0.13	0.0500	0.0141	0.24 -1	0.07 -1	12
Na	mg/l	5.7	0.7120	0.3184	6.6 -1	5.1 -1	5
K	mg/l	2.4	0.4207	0.1881	3.0 -1	2.0 -1	5
Daylength		14'50"			14'58"	14'40"	

Table 148. SUMMARY CHART - RUBIDIUM 6-30-72/7-18-72
Test 2 0.05 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.55°	---	---	24.44° -1	13.33° -1	19
pH		8.104	0.388	0.017	9.0 -3	7.2 -2	19
NO_3-N	mg/l	2.12	0.3266	0.1033	2.82 -1	1.72 -1	10
PO_4-P	mg/l	0.069	0.0411	0.0124	0.163 -1	0.023 -1	11
NH_3-N	mg/l	0.112	0.0766	0.0313	0.216 -1	<0.02 -1	6
SO_4	mg/l	20.5	--	--	21.6 -1	19.3 -1	2
SiO_2	mg/l	10.8	2.383	0.7538	15.2 -1	6.9 -1	10
Alk-P	mg/l	---	---	---	---	---	---
Alk-MO	mg/l	50.9	4.392	1.389	59.6 -1	44.4 -1	10
Cl	mg/l	9.6	--	--	9.6 -	9.6 -	1
Ca Hard.	mg/l	48.9	--	--	51.8 -1	46.0 -1	2
Tot. Hard.	mg/l	88.1	--	--	96.2 -1	80.1 -1	2
Rb	mg/l	0.055	0.0055	0.0000	0.067 -1	0.045 -1	16
Zn	mg/l	---	---	---	---	---	---
Cu	mg/l	---	---	---	---	---	---
Mn	mg/l	0.075	0.0646	0.0161	0.256 -1	0.022 -1	16
Fe	mg/l	0.14	0.0750	0.0214	0.35 -1	0.08 -1	12
Na	mg/l	5.6	0.6760	0.3023	6.4 -1	4.9 -1	5
K	mg/l	2.5	0.4506	0.2015	3.1 -1	2.0 -1	5
Daylength		14'50"			14'58"	14'40"	

Table 149. SUMMARY CHART - RUBIDIUM 6-30-72/7-18-72
Test 3 0.05 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.55°	--	--	25.56° -1	13.89° -1	19
pH		7.994	0.369	0.017	8.9 -4	7.2 -2	19
NO_3-N	mg/l	2.16	0.3515	0.1112	2.96 -1	1.79 -1	10
PO_4-P	mg/l	0.055	0.0318	0.0096	0.135 -1	0.023 -1	11
NH_3-N	mg/l	0.118	0.0625	0.0255	0.210 -1	0.050 -1	6
SO_4	mg/l	20.5	--	--	22.1 -1	18.8 -1	2
SiO_2	mg/l	9.6	2.759	0.8724	15.6 -1	5.8 -1	10
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	52.1	4.943	1.563	59.4 -1	44.4 -1	10
Cl	mg/l	10.0	--	--	10.0 -	10.0 -	1
Ca Hard.	mg/l	50.0	--	--	51.8 -1	48.2 -1	2
Tot. Hard.	mg/l	81.1	--	--	84.0 -1	78.2 -1	2
Rb	mg/l	0.054	0.0063	0.0000	0.073 -1	0.045 -1	16
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.061	0.0465	0.0114	0.156 -1	0.013 -1	16
Fe	mg/l	0.12	0.0501	0.0141	0.24 -1	0.06 -1	12
Na	mg/l	5.6	0.7602	0.3400	6.6 -1	4.9 -1	5
K	mg/l	2.4	0.4438	0.1985	3.1 -1	2.0 -1	5
Daylength		14'50"			14'58"	14'40"	

Table 150. SUMMARY CHART - RUBIDIUM 6-30-72/7-18-72

Test 4 Control

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.66°	--	--	24.44° -3	13.89° -2	19
pH		7.553	0.424	0.020	8.8 -2	6.9 -4	19
NO_3-N	mg/l	2.05	0.3936	0.1245	2.89 -1	1.66 -1	10
PO_4-P	mg/l	0.057	0.0316	0.0000	0.117 -2	0.019 -1	11
NH_3-N	mg/l	0.157	0.1406	0.0574	0.400 -1	<0.02 -1	6
SO_4	mg/l	20.9	--	--	21.9 -1	19.9 -1	2
SiO_2	mg/l	9.4	2.965	0.9375	15.2 -1	5.5 -1	10
Alk-P	mg/l	1.6	--	--	1.6 -	1.6 -	10
Alk-MO	mg/l	50.5	3.763	1.190	58.0 -1	45.8 -1	10
Cl	mg/l	8.8	--	--	8.8 -	8.8 -	1
Ca Hard.	mg/l	45.9	--	--	46.0 -1	45.8 -1	2
Tot. Hard.	mg/l	78.7	--	--	81.8 -1	75.6 -1	2
Rb	mg/l	0.0	--	--	0.0 -	0.0 -	16
Zn	mg/l	--	--	--	--	--	--
Cu	mg/l	--	--	--	--	--	--
Mn	mg/l	0.084	0.0746	0.0184	0.311 -1	0.017 -1	16
Fe	mg/l	0.11	0.0606	0.0173	0.26 -1	0.06 -1	12
Na	mg/l	5.8	0.6768	0.3027	6.5 -1	4.9 -1	5
K	mg/l	2.4	0.4147	0.1854	2.9 -1	1.95 -1	5
Daylength		14'50"			14'58"	14'40"	

Table 151. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 1 2.0 mg/l Rb

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.38°	3.253°	0.147°	22.22° -2	13.33° -1	491
pH		7.523	0.276	0.010	8.3 -2	6.5 -1	21
NO_3-N	mg/l	2.30	12.659	0.0738	2.76 -1	2.04 -1	13
PO_4-P	mg/l	0.060	0.0243	0.0063	0.092 -1	0.015 -1	14
NH_3-N	mg/l	0.075	0.0507	0.0179	0.178 -1	<0.02 -1	8
SO_4	mg/l	21.4	--	--	24.8 -1	16.5 -1	3
SiO_2	mg/l	12.0	1.694	0.4526	14.6 -1	9.96 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	53.0	5.428	1.451	65.8 -1	48.0 -1	14
Cl	mg/l	9.1	--	--	10.0 -1	8.2 -1	3
Ca Hard.	mg/l	50.3	--	--	51.0 -1	49.2 -1	3
Tot. Hard.	mg/l	81.9	--	--	84.0 -1	80.0 -1	3
Rb	mg/l	2.00	0.0616	0.0149	2.11 -1	1.87 -1	17
Zn	mg/l	0.011	--	--	0.011 -	0.011 -	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.117	0.1125	0.0228	0.300 -1	0.010 -1	24
Fe	mg/l	0.14	0.0763	0.0195	0.32 -1	0.03 -1	15
Na	mg/l	6.0	0.7559	0.2672	7.5 -1	5.3 -1	8
K	mg/l	2.2	0.1727	0.0609	2.5 -1	2.0 -1	8
Daylength		14'03"			14'23"	13'41"	21

Table 152. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 5 1.99 mg/l Rb

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	17.11	3.117°	0.1708°	20.56 -6	13.33 -1	332
pH		7.590	0.290	0.010	8.5 -1	6.7 -1	21
NO_3-N	mg/l	2.45	0.2705	0.0749	2.90 -1	2.19 -1	13
PO_4-P	mg/l	0.052	0.0232	0.0055	0.100 -1	0.010 -1	14
NH_3-N	mg/l	0.116	0.0762	0.0268	0.248 -1	<0.02 -1	8
SO_4	mg/l	21.6	--	--	25.7 -1	16.9 -1	3
SiO_2	mg/l	12.3	1.853	0.4951	14.7 -1	7.2 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	52.7	4.111	1.179	61.8 -1	45.0 -1	14
Cl	mg/l	9.5	--	--	10.0 -1	9.0 -1	3
Ca Hard.	mg/l	51.9	--	--	56.0 -1	49.0 -1	3
Tot. Hard.	mg/l	81.0	--	--	81.4 -1	80.8 -1	3
Rb	mg/l	1.99	0.0726	0.0176	2.09 -1	1.85 -1	17
Zn	mg/l	0.013	--	--	0.013 -	0.013 - 1	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.121	0.1197	0.0249	0.49 -1	0.012 -1	23
Fe	mg/l	0.13	0.0374	0.0095	0.21 -1	0.08 -1	15
Na	mg/l	5.8	0.4406	0.1558	6.3 -1	5.1 -1	8
K	mg/l	2.2	0.1885	0.0666	2.5 -1	2.0 -2	8
Daylength		14'03"			14'23"	13'41"	21

Table 153. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 6 1.0 mg/l Rb

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.83°	3.159°	0.173°	20.56° -5	11.67° -1	331
pH		7.650	0.365	0.014	8.9 -1	6.9 -3	21
NO_3-N	mg/l	2.31	0.3531	0.0979	2.93 -1	1.98 -1	13
PO_4-P	mg/l	0.050	0.0221	0.0055	0.091 -1	0.009 -1	14
NH_3-N	mg/l	0.081	0.0484	0.0170	0.168 -1	<0.02 -1	8
SO_4	mg/l	21.3	--	--	25.8 -1	16.1 -1	3
SiO_2	mg/l	10.6	3.094	0.8268	14.8 -1	6.4 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	54.6	5.413	1.447	68.0 -1	48.2 -1	14
Cl	mg/l	9.9	--	--	10.0 -2	9.6 -1	3
Ca Hard.	mg/l	53.9	--	--	57.0 -1	50.6 -1	3
Tot. Hard.	mg/l	80.3	--	--	81.0 -1	80.0 -2	3
Rb	mg/l	1.00	0.0517	0.0122	1.12 -1	0.94 -2	17
Zn	mg/l	0.010	--	--	0.010 -	0.010 -	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.100	0.0804	0.0173	0.32 -1	0.008 -1	23
Fe	mg/l	0.14	0.0432	0.0109	0.25 -1	0.06 -1	15
Na	mg/l	6.6	1.609	0.5688	9.5 -1	5.1 -1	8
K	mg/l	2.2	0.2549	0.0901	2.7 -1	2.0 -4	8
Daylength		14'03"			14'23"	13'41"	21

Table 154. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 2 1.0 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.38°	3.440°	0.155°	22.78° -2	13.33° -1	491
pH		7.646	0.409	0.017	8.9 -1	6.9 -6	21
NO$_3$-N	mg/l	2.33	0.3817	0.1058	2.90 -1	1.82 -1	13
PO$_4$-P	mg/l	0.059	0.0148	0.0032	0.088 -1	0.030 -1	14
NH$_3$-N	mg/l	0.079	0.0430	0.0152	0.154 -1	<0.02 -1	8
SO$_4$	mg/l	22.0	--	--	25.4 -1	16.6 -1	3
SiO$_2$	mg/l	11.8	1.972	0.5270	14.6 -1	8.96 -2	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	53.1	4.836	1.293	65.2 -1	46.8 -1	14
Cl	mg/l	9.6	--	--	10.0 -1	9.0 -1	3
Ca Hard.	mg/l	50.1	--	--	51.0 -1	49.6 -1	3
Tot. Hard.	mg/l	80.1	--	--	81.0 -1	79.2 -1	3
Rb	mg/l	1.00	0.046	0.0109	1.11 -1	0.94 -1	17
Zn	mg/l	0.012	--	--	0.012 -	0.012 -	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.101	0.0846	0.0170	0.300 -1	0.012 -2	24
Fe	mg/l	0.12	0.0445	0.0114	0.22 -1	0.06 -1	15
Na	mg/l	6.3	1.267	0.4479	8.5 -1	5.2 -1	8
K	mg/l	2.1	1.768	0.0624	2.4 -2	2.0 -4	8
Daylength		14'03"			14'23"	13'41"	21

Table 155. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 7 0.48 mg/l Rb

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	16.67°	3.199°	0.1757°	20.56° -1	11.67° -1	331
pH		7.688	0.348	0.014	9.0 -2	6.7 -1	21
NO_3-N	mg/l	2.24	0.4267	0.1183	2.94 -1	1.78 -1	13
PO_4-P	mg/l	0.045	0.0179	0.0045	0.080 -1	0.012 -1	14
NH_3-N	mg/l	0.083	0.0530	0.0187	0.168 -1	<0.02 -1	8
SO_4	mg/l	21.6	--	--	24.4 -1	16.6 -1	3
SiO_2	mg/l	10.0	3.693	0.9869	14.9 -1	4.8 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	54.3	3.031	0.8099	61.6 -1	50.0 -2	14
Cl	mg/l	9.1	--	--	10.0 -1	8.4 -1	3
Ca Hard.	mg/l	54.4	--	--	63.0 -1	50.0 -1	3
Tot. Hard.	mg/l	80.4	--	--	81.0 -1	80.0 -1	3
Rb	mg/l	0.48	0.1127	0.0272	0.60 -1	0.05 -1	17
Zn	mg/l	0.010	--	--	0.010 -	0.010 -	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.087	0.0836	0.0173	0.32 -1	0.014 -1	23
Fe	mg/l	0.12	0.0507	0.0130	0.25 -1	0.04 -1	15
Na	mg/l	6.9	1.914	0.6768	10.1 -1	5.2 -1	8
K	mg/l	2.1	0.1642	0.0581	2.3 -2	1.9 -2	8
Daylength		14'03"			14'23"	13'41"	21

Table 156. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 3 0.48 mg/1 Rb

Chemical or physical analysis		$\overline{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.27°	3.413°	0.151°	22.78° -1	13.33° -1	488
pH		7.610	0.271	0.010	8.4 -1	6.6 -1	21
NO_3-N	mg/1	2.39	0.2532	0.0702	2.79 -1	2.15 -2	13
PO_4-P	mg/1	0.061	0.0266	0.0071	0.111 -1	0.026 -1	14
NH_3-N	mg/1	0.081	0.0342	0.0118	0.132 -1	0.020 -1	8
SO_4	mg/1	21.5	--	--	25.6 -1	16.7 -1	3
SiO_2	mg/1	11.5	2.415	0.6455	14.7 -2	7.8 -1	14
Alk-P	mg/1	--	--	--	--	--	--
Alk-MO	mg/1	53.8	3.634	0.9711	64.4 -1	50.2 -1	14
Cl	mg/1	9.6	--	--	10.4 -1	8.4 -1	3
Ca Hard.	mg/1	51.1	--	--	52.0 -1	50.0 -1	3
Tot. Hard.	mg/1	80.8	--	--	81.6 -1	79.8 -1	3
Rb	mg/1	0.48	0.1141	0.0276	0.60 -1	0.05 -1	17
Zn	mg/1	0.006	--	--	0.006 -	0.006 -	1
Cu	mg/1	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/1	0.136	0.1392	0.0283	0.580 -1	0.009 -1	24
Fe	mg/1	0.14	0.0439	0.0114	0.24 -1	0.09 -2	14
Na	mg/1	5.9	0.8844	0.3127	7.9 -1	5.3 -2	8
K	mg/1	2.1	0.2031	0.0718	2.4 -2	1.9 -2	8
Daylength		14'03"			14'23"	13'41"	21

Table 157. SUMMARY CHART - RUBIDIUM 7-28-72/8-17-72
Test 4 Control

Chemical or physical analysis		$\bar{X}$	SD ±	SE ±	Maximum	Minimum	N
Temp.	°C	18.33°	3.314°	0.150°	22.78° -1	13.33° -1	489
pH		7.691	0.341	0.014	8.9 -1	6.8 -1	21
NO_3-N	mg/l	2.34	0.2977	0.0825	2.85 -1	2.07 -2	13
PO_4-P	mg/l	0.063	0.0257	0.0063	0.110 -1	0.026 -1	14
NH_3-N	mg/l	0.078	0.0416	0.0145	0.160 -1	0.020 -1	8
SO_4	mg/l	21.8	--	--	25.6 -1	16.9 -1	3
SiO_2	mg/l	11.3	2.252	0.6019	14.7 -1	6.7 -1	14
Alk-P	mg/l	--	--	--	--	--	--
Alk-MO	mg/l	53.2	2.141	0.5723	57.6 -1	50.0 -2	14
Cl	mg/l	9.2	--	--	9.8 -1	8.8 -1	3
Ca Hard.	mg/l	52.2	--	--	54.0 -1	51.0 -1	3
Tot. Hard.	mg/l	80.7	--	--	81.0 -1	80.2 -1	3
Rb	mg/l	0.00	--	--	0.00 -	0.00 -	17
Zn	mg/l	0.010	--	--	0.010 -	0.010 -	1
Cu	mg/l	<0.01	--	--	<0.01 -	<0.01 -	1
Mn	mg/l	0.146	0.1507	0.0307	0.640 -1	0.012 -1	24
Fe	mg/l	0.14	0.0538	0.0138	0.25 -1	0.07 -1	15
Na	mg/l	5.9	0.6610	0.2337	7.2 -1	5.1 -1	8
K	mg/l	2.1	0.1807	0.0639	2.4 -1	1.9 -2	8
Daylength		14'03"			14'23"	13'41"	21

APPENDIX C

DETERMINATION OF SELENIUM COMPOUND IN ALGAL BIOMASS

METHODS

General

The procedure for fractionation of the algal community from the slide is summarized in Figure 1. A total of one full side of one slide was used, with a 1/2-side area each for "portion 1" and "portion 2." Additional portions of the slides were used for pigment analyses according to the standard procedures.

All extractions with organic solvents were carried out by sonication (10 minutes) under ice cooling followed by centrifugation. Eight-ml. amounts of ether, acetone, and 70% methanol were used.

For the sodium hydroxide extraction, 1.2 mg 0.1 M NaOH was added to each residue in a small test tube and the mixtures were shaken at 40° in a water bath overnight. After centrifugation, 2.0 ml of 10% trichloroacetic acid solution was added. The tubes were refrigerated overnight and centrifuged. The pellets were hydrolyzed in 3 M HCl in teflon-lined screw cap test tubes under nitrogen at 110° overnight. The hydrolyzates were evaporated, redissolved in 0.1 M HCl and passed over 5-ml columns of Dowex-50 (H^+ form). After the column had been washed with 10 ml of 0.1 M HCl and 30 ml of triple distilled water, the amino acids were eluted with 20 ml of 3 M NH_4OH.

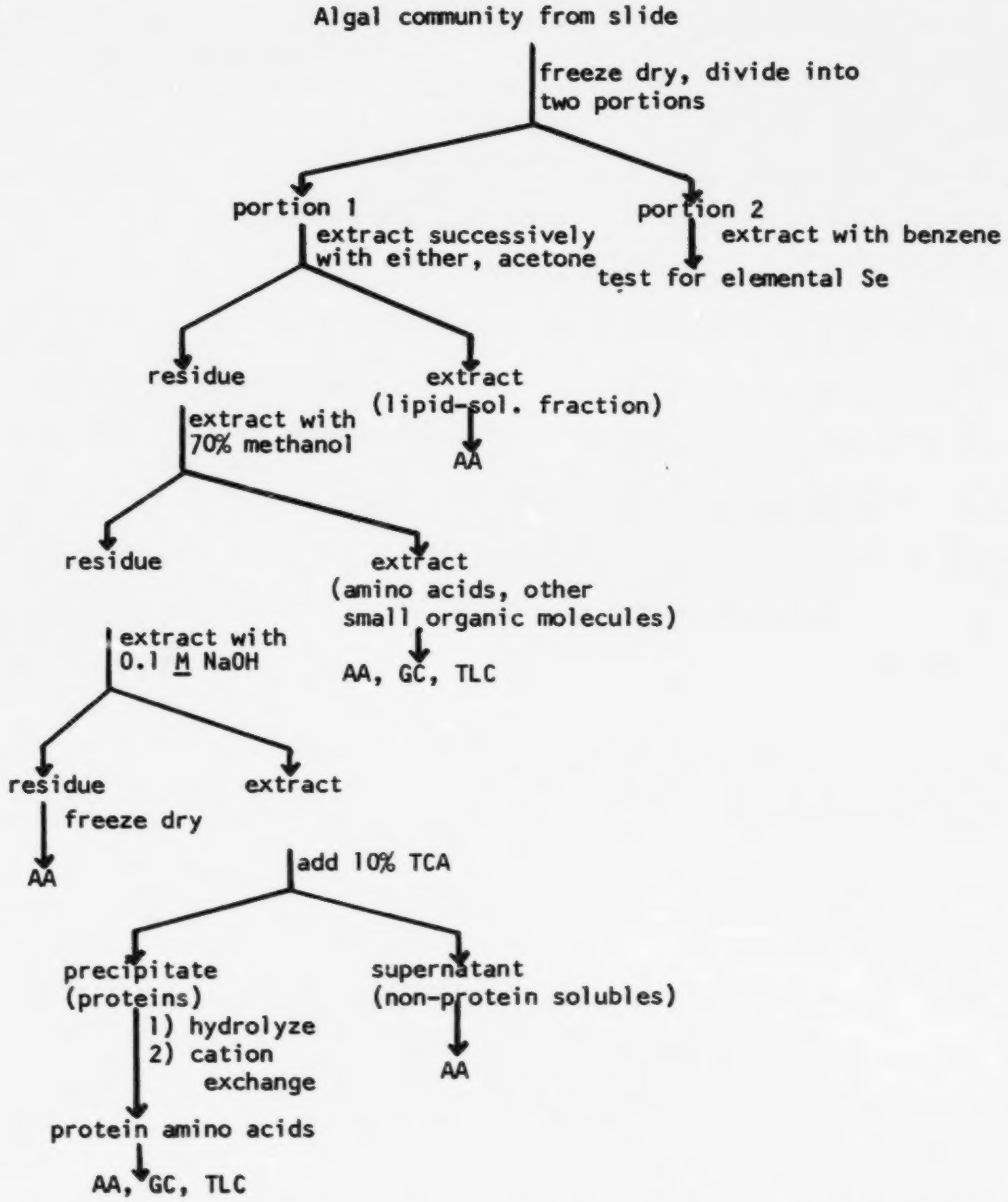
Algal community from slide
freeze dry, divide into two portions
portion 1
portion 2
extract successively with either, acetone
extract with benzene
test for elemental Se
residue
extract (lipid-sol. fraction)
AA
extract with 70% methanol
residue
extract (amino acids, other small organic molecules)
AA, GC, TLC
extract with 0.1 M NaOH
residue
extract
freeze dry
AA
add 10% TCA
precipitate (proteins)
supernatant (non-protein solubles)
1) hydrolyze
2) cation exchange
AA
protein amino acids
AA, GC, TLC

FIGURE 1. Chemical Fractionation of Algal Material from Slides
Abbreviations: AA=atomic absorption, GC=gas chromatography, TLC=thin-layer chromatography

Total Selenium

The selenium content of each fraction was determined by atomic absorption, using standard methodology.

Elemental Selenium

A modification of a spot test based on the selenium catalyzed bleaching of methylene blue by sulfide was used (Feigl[1]). To 1.0 ml of a benzene extract of an algal community (or to 1.0 ml of a standard benzene solution of selenium) was added 1.0 ml of a solution of methylene blue chloride (10-3%) in 90% methanol, followed by 1.0 ml of 0.2 M sodium sulfide in absolute methanol. The optical density of this mixture was read at zero time and at nine minutes, and the loss of absorbance at 559 nm (in percent) related to selenium concentration by means of a standard curve.

Selenite and Selenate

Selenite was detected using a minor modification of a standard colorimetric procedure (Snell and Snell[2]). It was established that sulfite, sulfate, selenate, and silicate did not interfere with the test.

Selenite and selenate were separated on Dowex-1 anion exchange resin columns (Schrift and Ulrich[3]).

Selenoamino Acids

Portions of fractions containing amino acids (the 70% methanol extract or the protein hydrolyzate) were spotted on silica gel thin-layer chromatography plates (20 x 20 cm) and developed in two directions, first with 2:2:1 chloroform: methanol: 17% ammonia, and second with 75:25 phenol:water (Randerath[4]). The amino acids were detected with ninhydrin. Spots occurring at the known positions for selenomethionine (partial overlap with methionine) or selenocystine (partial overlap with leucine and isoleucine) were scraped from the layer and analyzed for selenium by atomic absorption.

Another portion of each amino acid-containing fraction was derivatized (conversion of amino acids to n-butyl-N-trifluoroacetyl esters) and analyzed by gas chromatography using the method and conditions of Roach and Gehrke[5]. Using these conditions, selenomethionine emerges at 18.5 min relative to the standard (n-butyl stearate, 22.8 min) and is partly resolved from methionine (retention time 18.9 min). Selenocystine, however, appears to be destroyed and does not give a recognizable peak; the sulfur analog, cystine, behaves similarly.

RESULTS

Table 1 shows the distribution of selenium within each community. Columns 5-10 are in micrograms of selenium per half of one side of a slide; columns 2 and 11 show total selenium per slide as computed by direct digestion (column 2) and by summation of the extracts (column 11).

Table 2 shows the percent of the total selenium (determined by digestion) in each of the major fractions.

About a third of the total selenium is soluble in 70% methanol. This solvent would be expected to extract most small polar organic molecules, such as amino acids, and also some inorganic salts. Two dimensional thin-layer chromatographic studies on the extract from the 40 ppm community showed a spot at the expected position of selenomethionine, but when this spot was scraped off and analyzed by atomic absorption, no selenium could be detected. It should be noted that methionine overlaps with the selenomethionine spot and may have been the amino acid detected. Five other spots were observed in the extract from this box; none could be seen at lower concentrations. Likewise, gas chromatography did not show free amino acid peaks.

The bulk (62-85%) of the selenium in the 70% methanol extracts was shown to be in an inorganic form (selenite) by a colorimetric method specific for selenite. Selenite also appeared to be present in the fraction soluble in sodium hydroxide and trichloroacetic acid, but because of apparent interference by trichloroacetic acid, no quantitative data could be obtained.

No tests were made to show whether inorganic selenium or selenate or selenium-containing organic compounds other than amino acids were present in either extract.

In almost all communities, the bulk of the selenium was associated with residual sodium hydroxide-insoluble material after all extractions had been carried out. Although the chemical form of this material could not be determined, it is possible that it may consist of finely divided selenium, generated during the alkaline extraction procedure through decomposition of selenotrisulfides, which are known (Ganther[6]) to be unstable to base.

Elemental selenium appears to be initially absent from most of the communities; it may possibly be present in those exposed to the higher concentrations, but the data are incomplete. No red granules could be observed microscopically.

Lipid-soluble selenium (that extractable by ether or acetone) appears to constitute less than 1% of the total selenium taken up, at least in the high-concentration communities.

Little or no amino acid-associated selenium was present in any of the protein hydrolyzates from the communities.

Some of the selenium taken up by the communities may have been converted to volatile compounds as indicated by column 6, Table 2. In one case, 33% of the total selenium found by digestion was not accounted for by soluble and residual forms, and in several other cases about 10% seems to be missing.

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Table 1. DISTRIBUTION OF SELENIUM

Box Se conc.	ug Se/slide (digestion)	mg dry wt. ¼ slide community	% Se per community	ug elemental Se	ug lipid sol. Se	ug 70% MeOH sol. Se	ug NaOH sol., TCA sol. Se	ug NaOH insol. Se	ug Se protein hydrolyzate	Sum Columns 6-9 (x4)
40	274	25.5	0.27	---	<0.4	23.5	8.9	29.0	0.10	247
20	342	36.9	0.23	5.5	<0.4	19.0	7.6	30.0	<0.05	228
10	205	27.5	0.18	13.2	---	20.0	5.2	22.0	0.15	189
5	105	18.2	0.14	0	---	9.0	3.2	15.0	0.15	109
3	53	14.3	0.09	0	---	4.5	2.5	5.0	<0.05	48
1	23	15.6	0.04	0	---	2.0	1.2	2.0	<0.05	21
0.1	10	15.5	0.02	---	---	0.5	0.6	1.0	<0.05	8
0	<8	10.5	<0.01	---	---	<0.25	<0.5	<0.5	<0.05	<5
2nd experiment										
40	82	19.4	0.10	0	---	12.2	2.6	5.5	0.1	82
10	78	24.2	0.08	---	---	5.8	3.1	10.0	0.1	76
0.1	<6	16.7	<0.01	---	---	1.5	0.6	0.6	<0.05	11

Table 2. PERCENT OF TOTAL SELENIUM IN EACH FRACTION

Box Se conc.	Lipid -sol.	70% MeOH -sol.	NaOH TCA sol.	NaOH insol.	4-column total	% unacc. for (volatile?)
40	<0.6%	34.3%	13.0%	42.3%	90.2%	9.8%
20	<0.5	22.2	8.9	35.1	66.7	33.3
10	---	39.0	10.1	42.9	92.0	8.0
5	---	34.3	12.2	57.1	103.6	---
3	---	34.0	18.9	37.7	90.6	9.4
1	---	34.8	20.9	34.8	90.5	9.5
0.1	---	20.0	24.0	40.0	84.0	16.0
2nd experiment						
40	---	60.8	12.9	26.8	100.5	---
10	---	29.6	15.9	51.3	96.8	3.2
0.1	---	100.0	43.3	41.6	184.9	---